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DISTRIBUTION, NUMBERS, AND MORTALITY OF GRIZZLY BEARS IN AND AROUND KANANASKIS COUNTRY, ALBERTA

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DISTRIBUTION, NUMBERS, AND MORTALITY OF GRIZZLY BEARS IN AND AROUND KANANASKIS COUNTRY, ALBERTA

HAROLD D. CARR
Wildlife Research Biologist

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DISTRIBUTION, NUMBERS, AND MORTALITY OF GRIZZLY BEARS IN AND AROUND KANANASKIS COUNTRY, ALBERTA

Wildlife Research Series Number 3

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ABSTRACT

Grizzly bear (*Ursus arctos horribilis*) distribution, numbers, and mortality were investigated to enhance bear conservation and human safety in Alberta's Kananaskis Country, a rapidly developing recreation area along the Rocky Mountains. Data were obtained from 25 grizzlies snared, marked (21 radio collared), and released 46 times between 1980 and 1984.

Cub, subadult, and adult groups each accounted for 1/3 of the males and 1/3, 1/6, and 1/2, respectively, of the females in 1980 — a relatively balanced, young, and productive age structure. Known annual mortality averaged 9.8% for males and 3.4% for females, an overall rate of about 6.6%. All mortality was man-caused, 2/3 due to sport hunting and 1/3 to self-defensive actions; 2/3 of it occurred outside Kananaskis Country. Bears under 2 years old were not monitored and natural mortality was not detected.

Grizzlies occurred throughout the study area but were more common in remote habitats least affected by human activities. Complete annual home ranges averaged 1183 km^2 for males and 179 km^2 for females. Grizzly densities were conservatively calculated to be 69 and 82 km^2 /bear by applying capture-recapture estimates of the population to the multi-annual home range polygons for females and males, respectively.

Kananaskis Country bears are an interprovincial resource, and their welfare is dependent on decisions made in both Alberta and British Columbia. Sport hunting is justifiable if it remains carefully controlled and focused on males to ensure adequate protection of females in each province. For the mutual benefit of bears and people, plans for human developments and activities throughout the Kananaskis area must consider the presence of grizzlies. Major activities should be minimized or avoided in better habitats where higher concentrations of grizzlies can be anticipated. Grizzly mortalities resulting from the self-defensive actions of humans need to be thoroughly examined to find means of prevention.

1.0 INTRODUCTION

The grizzly bear is a high profile and significant component of Alberta's wildlife. It is a wilderness-seeking species that exists usually at low densities. Although grizzlies once ranged east across the plains, today, in Alberta, the only suitable habitat remaining south of the Bow River is the narrow (30–60 km) strip of unsettled forest land along the Rocky Mountains. The area is intensively managed for oil and gas, grazing, and timber resources, and is also heavily affected by human recreational activity (Alberta Resource Evaluation and Planning Division 1986). To the west, in British Columbia, there is also major coal mining activity.

Grizzlies were essentially extirpated from Alberta's plains by the late 1800s (Nielsen 1975). In the mountain areas around what is now Kananaskis Country, grizzlies remained relatively secure until the 1940s (McCrory and Herrero 1982). By the 1960s, however, grizzly numbers were greatly depleted and restricted to only the most remote habitats (Collins 1969; Jamieson 1969). This depletion was caused mainly by the killing of bears to protect livestock or resolve other conflicts with people. Inadequately controlled sport hunting was also a factor (McCrory and Herrero 1982). The latter followed elimination of the Kananaskis Game Preserve and increased accessibility to the area created by construction of roads like the Kananaskis-Highwood Highway.

Although 4 wildlife management units were reopened on a limited basis (total of 50 permits) in spring 1982, grizzly hunting had been closed in southwestern Alberta since the 1970 spring season when the bear's precarious status in this part of Alberta was recognized. The population responded positively, even though, according to McCrory and Herrero (1982), the closure reduced known mortality by only about half. A substantial resurgence — based on increased complaints as well as sightings and reports from officers, biologists, survey crews, and the public — became subjectively apparent to Fish and Wildlife staff in the late 1970s.

The numbers of complaints and sightings of grizzlies received by the Fish and Wildlife Division increased dramatically after 1978 (Nagy and Gunson 1988). In the Eastern Slopes Region, of which Kananaskis Country is a part, the numbers increased from an average of 1.8 to 3.4 to 32.2/year during 1970–74, 1975–79, and 1980–84, respectively. From 1985–87, the numbers increased further to 52.5/year.

Just as the expansion in grizzly numbers became apparent, the Alberta Government began massive recreational development in the area which became known as Kananaskis Country. The proposed developments (now existing) included, among other things, an alpine village, a 36-hole golf course, downhill and cross-country ski areas, and off-highway vehicle and snowmobile areas. It was obvious that serious conflicts with grizzly bears would be possible, especially with other recreational developments emphasizing new and expanded campgrounds, backcountry trail systems, and major highway construction to attract vastly greater numbers of people into this narrow strip of wildland. At considerable cost in lost resources, grizzlies seem to avoid habitats alienated by human activity (Mattson et al. 1987; Archibald et al. 1987). Conversely, they also are often attracted to areas of human activity in search of food, a situation in which potential for bear-human interaction and human injury is high (Herrero 1985; Warner 1987). Elimination of offending bears is an unfortunate but frequent and ultimate result.

Fortunately the Kananaskis development policy also called for a major effort to maintain and enhance the area's wildlife resources. Thus, the Fish and Wildlife Division began a series of grizzly bear investigations to evaluate the status of the grizzly, ensure its conservation, and provide information for intelligent planning of recreational facilities in order to protect both bears and people (Herrero et al. 1986). Ensuring the coexistence of grizzlies and humans in such a narrow strip of intensively used habitat was, and continues to be, a major challenge — a challenge best met by a sound understanding of the local ecology of grizzly bears.

The primary objectives of this report are as follows:
(1) to evaluate the sex and age structure of the population;
(2) to evaluate the causes and rate of grizzly mortality;
(3) to describe the distribution and home ranges of grizzly bears in the area; and
(4) to estimate the size and density of the grizzly population.

2.0 STUDY AREA

The study was initiated in 1980 in Kananaskis Country, a recreational area lying along the east slopes of the Rocky Mountains, 50 km southwest of Calgary. Two trapping areas were established. The first, in the foothills east of the front mountain ranges, was centered on the Sheep River area and was intended primarily for concurrent studies of black bears (*Ursus americanus*). The second, in the mountains west of the front ranges, was centered on the Highwood area and was expected to emphasize grizzlies (Fig. 1).

The areas were selected in order to gather information about bears that could be used relative to Kananaskis Country development. Also, they were located in Kananaskis Country's southern half, a portion planned for more extensive recreational pursuits such as hunting and backpacking, rather than intensive activities and major development. This lower level of activity was considered essential for the study to progress without excessive interference from recreationists. It was also essential to minimize the chance of recreationists inadvertently encountering grizzlies near bait and trapsites.

Although this study was to focus on the grizzly bears of Kananaskis Country, it soon became apparent that the bears of interest were residents of a much wider area. Since much of the study involved monitoring bear movements with radio telemetry, the boundaries of the study area were left "open" to be defined eventually by the movements of the bears. As such, no finite boundary is shown in Fig. 1. The core of the study area, Kananaskis Country, is described in detail by McGregor (1984).

This "open" study area straddles the Continental Divide, which here forms the Alberta-British Columbia border. The Divide is paralleled to the east by several mountain ranges, notably the Livingstone, Highwood, and Misty ranges in the south; the Kananaskis, Opal, and Fisher ranges farther north. To the west in British Columbia, another mountain range forms the western boundary of the Elk River drainage. This is rugged terrain with many mountains extending beyond the 2125-m treeline to elevations over 3000 m. The flatter valley bottoms lie mostly between 1500 and 1800 m, with lower elevations down to about 1300 m along the eastern edge of the foothills.

The Kananaskis, Elbow, Sheep, and Highwood rivers drain the area generally north and east into the Bow River. The Oldman River drains the area southeasterly; the Elk, White, and Palliser rivers drain south and west into the Kootenay River in British Columbia.

Although quite variable and strongly influenced by topography, climatic conditions are generally cool and moist in spring and early summer, warm and often dry in the late summer and early fall. Average precipitation varies from about 570 mm yearly at lower elevations on the east, to 730 mm in alpine areas along the Continental Divide on the west; much of it falls as snow in winter. Winters are generally cold, but they are frequently warmed by chinook winds from the Pacific Ocean.

Most of the area is covered by subalpine forest characterized by alpine fir (*Abies lasiocarpa*) and Englemann spruce (*Picea engelmanni*) at higher elevations, spruce and lodgepole pine (*Pinus contorta*) at mid to lower elevations. The boreal foothills zone occurs at lower elevations to the east of the subalpine forest. Pine and aspen (*Populus tremuloides*) are the most common trees. Montane forest occurs sporadically, usually in locations most influenced by chinook winds. Aspen parkland forms a narrow band along the eastern edge of the study area. All forest zones have been heavily influenced by fires, the last major one burning in 1936. The extensive fire history has been described for parts of the area by Jaques (1980). Above the subalpine forest, there are extensive areas of alpine vegetation (*Dryas* spp., *Kobresia* spp., *Phyllodoce* spp., *Salix* spp., etc.), barren rock, and even ice fields at the highest elevations.

Common vegetative grizzly foods in the area, besides grasses and sedges (*Carex* spp.), were *Hedysarum* spp., *Shepherdia canadensis*, *Vaccinium* spp., *Erythronium* sp., *Heracleum lanatum*, *Equisetum* spp., and *Vicia* spp. Fire history has a significant impact on the production of many of these species. Wielgus (1986), McCrory and Herrero (1981, 1983*a*,*b*), and McCrory et al. (1982) further describe the grizzly habitats and foods of the area.

The area was rich with wildlife. Besides grizzly bears, black bears were also common. Indicative of the area's wildland characteristics, cougars (*Felis concolor*), wolverines (*Gulo luscus*), lynx (*Lynx canadensis*), and wolves (*Canis lupus*) occurred here as well. Other large mammals included bighorn sheep (*Ovis canadensis*) and mountain goats (*Oreamnos americanus*) at generally higher elevations. Moose (*Alces alces*) and deer (*Odocoileus hemionus* and *O. virginianus*) were most common in the foothill areas, but elk (*Cervus elaphus*) was perhaps the most common large mammal in areas used by grizzlies. Smaller mammals of some importance as grizzly foods were

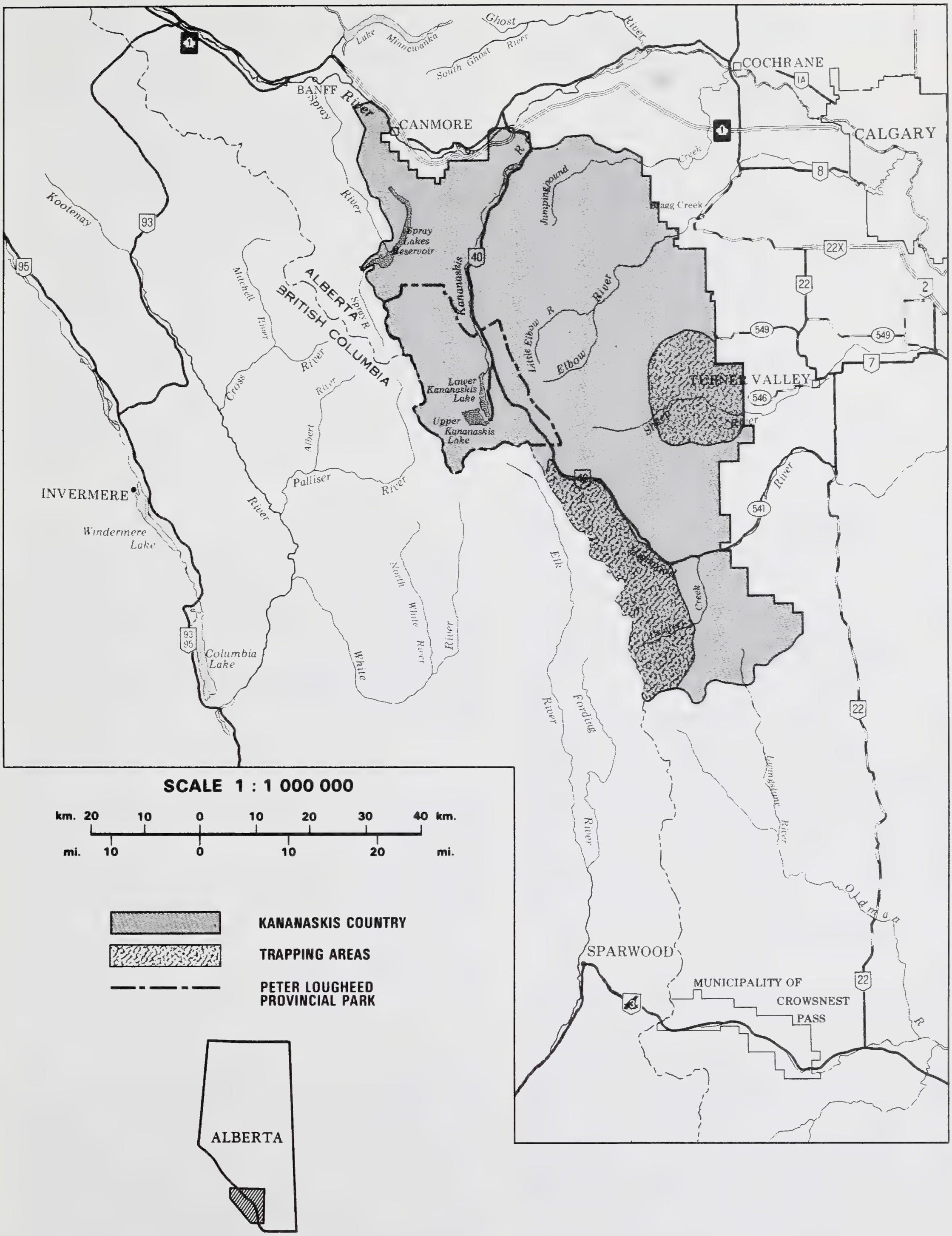

Fig. 1. The location of the general bear study area, the trapping areas, and Kananaskis Country.

ground squirrels (*Spermophilus columbianus* and *S. lateralis*) and marmots (*Marmota caligata*).

3.0 PROCEDURES

3.1 Capture and Handling

Trapping was initiated by Fish and Wildlife personnel in May 1980, with initial efforts aimed at establishing suitable baiting sites and learning how to catch and handle grizzlies. The first snares were set in early June in the Sheep River area and late July in the Highwood. The work was contracted to Rocky Mountain Wildlife Research, a consulting partnership, on 1 September 1980. The total effort expanded considerably at that time, and it continued at a high level through 1981, 1982, and 1983. Although responsible to Alberta Fish and Wildlife, and also receiving assistance from the Division, Rocky Mountain Wildlife Research continued, under subsequent annual contracts, to provide most bear trapping, handling, and marking services through 1981, 1982, and 1983. The budget was eliminated in 1984, and the trapping effort was reduced to 118 trap-nights provided by a graduate student.

Bears were captured from May through October in spring-activated Aldrich foot snares made from galvanized aircraft cable. The swiveled anchor cable was 5/16 inch in diameter; the snare cable was 1/4 inch and was discarded after each capture. Traplines were maintained throughout the trapping areas (Fig. 1) but close to major roads and trails for ease of access. Trap sites were established by baiting the area with portions of road-killed ungulates, nuisance-trapped beaver, or other meat scraps at 1–2 km intervals along the traplines. Snares, usually in a cubby set accompanied by one or more trail sets, were activated immediately following any sign of bear activity.

Trap and bait sites were checked daily. Signs were also posted around these sites to warn people of their presence and potential danger. Whenever a bear was captured, the main access trail into the pertinent valley was legally closed to public travel, and signs were posted to that effect. The closure was maintained, usually for a couple of days, until the bear recovered and left the area. The signs and closures were deemed necessary to minimize the chances of people encountering either a trapped bear or one still affected by its processing.

Using Cap-Chur dart gun equipment (Palmer Chemical Co., Douglasville, Ga.), the field crew immobilized snared bears with ketamine hydrochloride and xylazine hydrochloride (Addison and Kolenosky 1979). The drugs were concentrated to 200 mg each/ml and given in a 1:1 mixture. The crew attempted to deliver, intramuscularly, a dosage of 9.9 mg of each drug/kilogram of the bear's estimated body weight. Larger dosages of 11 mg/kg are now preferred (Carr 1989). The dart wound was treated with an antiseptic, and the bear's eyes were protected with opthalmic salve.

The snare cable was transferred to a different leg to keep the bear secured, while enabling any necessary treatment of the originally snared leg. A premolar (usually upper PM 1) was extracted and preserved in a solution of glycerine, water, and formalin. Numbered 5-cm plastic tags were placed in each ear, red for males and green for females in the Highwood. The 3 males captured in the Sheep River area were given blue tags. In most cases, an additional small metal tag was placed at the base of one ear. The upper lip was tattooed with an identification number.

The bear was weighed to the nearest kilogram by raising it with a block and tackle attached to a dial scale suspended from a tree or tripod. Various body measurements were taken, and heart and respiration rates and rectal temperatures were recorded. The snare was removed from the bear after processing had been completed and personnel were ready to leave.

3.2 Radio Telemetry

Starting in 1981, captured grizzlies were fitted with radio collars, each with a unique frequency. Most transmitters were equipped with mortality- and activity-sensing capabilities. Radio locations were obtained mainly from fixed-wing aircraft with strut-mounted dual yagi antennae. As much as possible, given weather, budget, and time constraints, bears were relocated every 1–2 weeks. Locations were plotted on a 1:50,000 topographic map.

3.3 Data Analysis

The analysis and interpretation of the data, although influenced by Rocky Mountain Wildlife Research, were the responsibilities of the Fish and Wildlife Division and were done by the author. A data base of all capture and radio-telemetry data was created on the Honeywell MULTICS at the University of Calgary. These data were analyzed with SPSS and PLI programs written specifically for the data base.

3.3.1 Sex and Age Structure

Teeth extracted from captured bears were later sectioned and stained and then aged by counting cemental annuli (Mundy and Fuller 1964; Pearson 1975). The sex and age structures of the captured bears were determined by backdating the age of each bear to 1980, the only year that all 24 were alive. Sex and age structures were calculated similarly for 1981, 1982, and 1983. However, there was a cumulative loss of newborns in 1981, yearlings in 1982, and 2-year-olds in 1983, by which time the 1980 cubs had aged to 3-year-olds and joined the subadult group. Also, 3 bears died during this period, leaving only 21 marked by 1983. The 1984 structure would not be comparable since by then there were no 2-year-olds remaining to advance to the subadult group which, consequently, began to dwindle.

3.3.2 Mortality

Mortality was evaluated by continued recording of all known deaths of marked bears. These data were supplemented and their interpretation aided by data from Fish and Wildlife records of all known grizzly bear mortalities in Alberta (Gunson and Treichel 1987). Most man-caused mortality in southern Alberta was believed to be soon detected by or reported to the Fish and Wildlife Division.

Calculations of marked bear mortality — representations of population mortality — were based only on bears marked and subject to mortality while being monitored for a full year. An annual mortality rate was the percentage of grizzlies present and marked on 1 January that died by 31 December of the year in question. Bears marked during a year were excluded from that year's analysis since they were not subject to a full year's potential mortality while marked. One mortality (H6) also was excluded because the bear died only 2.5 months after marking and was not in the sample on 1 January 1981, the year he was marked, nor on 1 January 1982. The trap-related mortality (H4) was also excluded from this analysis because she was never returned to the population and her death was not representative of normal mortality affecting the population.

3.3.3 Distribution

Capture and relocation points were plotted by computer. Annual home ranges were outlined by connecting the extreme peripheral points to form polygons enclosing the year's locations for each bear. This is the minimum convex polygon home range method (Mohr 1947) used in most grizzly bear studies. The area of the polygon was calculated by computer.

The technique is simple but has some interpretive shortcomings. Home range area is biased by sample size in that, generally, the greater the number of locations the greater the area of the home range. However, the significance of this bias decreases with increased sample size. Unlike studies dependent on retrapping or chance reobservation, relocations here were generated by radio-telemetry; most home ranges, therefore, are based on reasonable numbers of bear locations. Nevertheless, sample size bias is a concern, particularly with home range areas based on less than 10 observations.

Of greater concern is the distribution of observations over time. Home ranges of grizzlies, especially males, are often immense (Canfield and Harting 1987), partly because of occasional long-range movements, either to dens and seasonal feeding sites, or associated with breeding activity. Because of seasonal changes in distribution, home ranges based on observations that do not cover the entire active period (April–December) are suspect and do not represent complete annual home ranges.

3.3.4 Population Estimates

Grizzly populations have been estimated by extensive direct observation and recording of individually identifiable bears (Mundy and Flook 1973; Martinka 1974; Nagy and Russell 1978; Russell et al. 1979; Nagy et al. 1983*b*). A minimum population size was determined in this way.

In an effort to estimate the total population, various capture-recapture techniques were examined. Because of the long time period over which marking and recapture sampling occurred, the assumption of demographic closure seemed doubtful. Therefore, the Jolly-Seber technique, appropriate for demographically open populations, was tried (Jolly 1965; Seber 1965). Because grizzly bears occurred at low density, however, the capture rate was low and produced insufficient capture, mark, and recapture data to work the Jolly-Seber model.

Assumptions of demographic closure can be met if there is no unknown change in the population (White et al. 1982). Because of the low reproductive rate of grizzlies, and because every captured bear was aged, the effects of reproduction could be excluded. The effects of emigration and mortality can be accommodated if they have an equal impact on marked and unmarked bears, a seemingly reasonable assumption for this study. Mortality records combined with proof of survival and presence (mainly from telemetry) provided additional control over these factors.

The assumption of closure could be questioned because the study population was geographically open and immigration likely occurred from extensive habitats to the north, west, and south. However, the number of marked bears in the population immediately before and during the recapture sampling periods could be specified because of radio telemetry, even though they may have been marked as much as 3 years previously. Because there was no time lapse between marking and the start of recapture sampling, the population could not change substantially through immigration during the interval. However, the long resampling periods, especially those longer than 1 year, likely produced estimates influenced by immigration. Long resampling periods would have been a serious problem if the population estimates applied to the time of marking. These estimates apply to the recapture sampling periods and, therefore, seem more representative of the actual immigration-influenced population. Each estimate presumably would best apply to the midpoint of its sampling period, and clearly the shorter the sampling period the more meaningful the estimate.

Based on these considerations, I decided that the assumption of demographic closure could be met approximately. A modified Petersen estimator (Petersen 1896) was used to estimate the size of the population. Because sample sizes were too small, Chi Square could not be used to test for differential catchability between marked and unmarked bears. However, the results of such tests, if non-significant, are ambiguous anyway. They do not separate compound from simple poisson distributions and, in a compound distribution such as this, may indicate equal catchability incorrectly (Caughley 1977).

In this study, the sex ratio of marked bears (3.3 males to 1 female), combined with the tremendously greater mobility and home range size of males, showed conclusively that there was substantially greater opportunity to catch males than females. Because unequal catchability is often the greatest source of error in mark-recapture estimates, particularly when caused by unequal opportunity, male and female numbers were estimated separately.

The capture histories of 22 bears were used in the model. Three of the 25 captured bears were removed from all calculations: H4 was a trapping mortality; H8, a Montana nuisance bear, was not considered to be part of the study population; and K1 was a male captured north of the trapping area in Peter Lougheed Park. K1 was relocated 18 times over the next year, but he never came south into the trapping area and was not considered to be part of the population being censused by the capture-recapture technique. Because his home range did not contact the trapline, he had no chance of capture there.

In spite of its simplicity and apparent logic, the basic Petersen equation N = Mn/m produces excessive and biased estimates (Caughley 1977). Chapman's modification

$$N = \frac{(M+1)(n+1)}{m+1}$$

produces more conservative figures which are unbiased in most instances (Ricker 1975). Unfortunately, the small sample sizes in this study (e.g., recaptured marks less than 4) provide a situation in which the estimator has a negative bias and would underestimate the population. These estimates, therefore, should be viewed as minimums.

All reasonable combinations of marking and sampling periods (that provided sufficient data to fuel the model) were used to produce estimates of population size for males and females. In order to avoid the effects of natality as well as unequal catchability, only bears 3 years and older were considered. Females H11 and H12 were excluded from the calculations until they reached this age.

3.3.5 Population Density

The basic estimates produced by the Chapman model apply to the respective populations of males and females whose home ranges contacted the trapline, but both figures have limited meaning unless related to some area. Identification of this area is a major problem when the population is not isolated in some way.

The literature deals with determination of effective trapping area (Otis et al. 1978), but none of the procedures seemed appropriate for this study. Traps were neither set randomly nor systematically, nor were they operated with equal effort. Calculation of a boundary strip based on home range diameters seemed questionable, especially for elongated male ranges.

If the trapping area is large relative to the size of home ranges, the effective trapping area approximates the actual trapping area. However, in this case where the trapping area was tiny relative to the home ranges, the population estimate was clearly excessive for the trapping area. Bears were trapped from an area much larger than that covered by the traplines.

Some authors (White et al. 1982) feel that a valid density estimate is not obtainable in a situation like this where the trapping grid is very small relative to home range size. However, some limits and evaluation can be provided for the population estimates by calculating densities for the collective home ranges.

Because the home ranges were based on 549 telemetry relocations for 19 radio-collared bears over 4 years, it seems clear that these bears confined the vast majority of their activity to their collective 6286 km^2 multi-annual home range polygon. This polygon encloses the collective 1033 km^2 multi-annual polygon to which the known female activity was confined. Comparable areas would be difficult to duplicate for another study, but they are measurable areas that apply to this population and this study. Population density was calculated by applying the adjusted male estimate (24.1 males adjusted to 77 bears) to the multi-annual home range polygon for all bears. A second density estimate was calculated by applying the adjusted female estimate to the multi-annual home range polygon for all females.

4.0 RESULTS AND DISCUSSION

4.1 Bear Trapping and Marking

Trapping activity is summarized in Table 1. The major increase in both total and individual captures after 1981 was likely due to the crew's added experience and enhanced efficiency, along with increased availability of bait. Capture rates in the latter years were comparable to rates achieved by Russell et al. (1979) in Jasper Park. The capture rate remained high in 1984, but only 2 recaptures were achieved because the trap-nights were reduced almost 8-fold. The major difference in capture rates between the Highwood (1 capture/93 trap-nights) and the Sheep (1/1358) trapping areas was indicative of the distribution of grizzlies.

Twenty-five grizzly bears were captured and immobilized a total of 46 times between 1980 and 1984. Forty-five of the 46 captures were handled successfully with no major problems. One female (H4) was shot when she recovered from the drug too quickly and charged the crew. Twenty-four individuals, 18 males and 6 females, were marked (21 radio-collared) and released between 1980 and 1983. Trapping results are summarized in Table 2, and the individual bears, their history, and fate as currently known are summarized in Table 3.

4.2 Sex and Age Structure

The sex and age distributions of 24 captured bears are displayed in Table 4 and Fig. 2. Because of the much greater mobility and home range size of male grizzlies, the sex ratios of the captured bears are biased towards males and are not representative of the population. There are no data from which to determine the population sex ratio, but there is no reason to believe it would differ substantially from that of other grizzly populations in similar situations. Because of biases in the various capture or sampling techniques, ratios from other studies are not easily comparable. Reported sex ratios were variable and often reflected some "captured group" rather than the actual populations. Harting (1987*a*) summarized age and sex ratios calculated mainly from capture records of studies in various areas of North America. Adult sex ratios varied from about 28–85% females, but females predominated in most studies presumably because males suffered greater hunting mortality. In the subadult group, males usually predominated but they ranged from about 30–75%.

The age structures of captured bears (Fig. 2) probably were reasonably representative of each sex class in 1980, although the female sample was very small. Age structure is dynamic, changing from year to year as different sized year classes advance from one age group to the next. The average adult:subadult ratio of marked bears over the 1980–1983 period was 1.25:1 for males and 2.75:1 for females (Table 5). The ratio for total bears is meaningless because male and female age structures differ and males are over-represented in the sample.

The age structure shows a reasonable number and proportion of older bears, perhaps indicative of a somewhat protected population. Most grizzly studies report bears beyond 14 years of age, but

Table 1. Grizzly bear trapping activity, effort, and success in the Sheep and Highwood areas from 1980–1984[a].

Trapping		Number of				Trap-nights /capture
Area	Years	Trap sites	Trap-nights	Captures	Individuals	
Highwood	1980	?	958	6	5	160
	1981	28	891	5	4	223
	1982	26	1015	14	8	72
	1983	28	934	15	9	62
	1984	6	118	2	2	59
	Total 1980–84		3916	42	21[b]	93
Sheep	1980	?	848	0	0	
	1981	32	1183	1	1	1183
	1982	34	1109	0	0	
	1983	24	934	2	2	467
	1984	0				
	Total 1980–84		4074	3	3	1358

[a] One additional bear (K1) was snared in Peter Lougheed Park in 1982.

[b] This total is not the sum of the individuals caught each year, since some were caught in more than 1 year.

the ages herein have been backdated to 1980. By 1987, the 3 oldest bears still alive would be 19, 20, and 21 years old.

The age structure is generally balanced between cub, subadult, and adult groups. They comprise 1/3, 1/6, and 1/2 of the females, respectively, and 1/3 each of the males in 1980. Overall, the population appeared relatively young and productive. The scarcity of bears over 14 years old may be further evidence of population expansion since the mid-1970s, with young grizzlies immigrating and establishing residence in areas unoccupied by older bears.

Although these bears had been hunted in British Columbia, there had not been a hunting season for grizzlies in southern Alberta after the spring of 1970 until 1982. Hunting seasons were reopened in parts of the study area in 1982; therefore, chances of males living to advanced ages will be decreased and their future age structure should reflect this.

Compared to others in Alberta, the Kananaskis population had a higher proportion of adults than the 20.8% found in the Swan Hills (Nagy and Russell 1978), but a lower proportion than the apparently old populations found in Jasper Park (67%) by Russell et al. (1979) and in the Berland area (63.1%) by Nagy et al. (1988). The Berland study included 5-year-olds in the adult category, thereby raising its proportion of adults somewhat above the proportion in the other studies which included only bears 6 years and older. The

Table 2. Summary of grizzly bear trapping results in Kananaskis Country.

Number of	1980	1981	1982	1983	1984	Total
Captures	6	6	15	17	2	46
Individuals	5	5[a]	9[b]	11	2	25[c]
New bears	5	5	6	9	0	25
Recaptures	1	1	9	8	2	21
Recaptures of that year	1	1	4	5	0	11
Recaptures from previous years	0	0	5	3	2	10

[a] One female was a released problem bear that left the study area after capture and has been excluded from most data evaluation.

[b] Includes K1 which was caught in Peter Lougheed Park.

[c] The total individuals caught (25) is not the sum of the individuals caught each year, since some were caught in more than 1 year.

proportions of adults in the Jasper and Berland populations are mathematically higher than in the Kananaskis population, partly because of their poor production and low proportions of cubs.

The age structure data provides information on grizzly production. The 8 cubs and 7 subadults in 1980 (compared to 9 adults) suggest that production had been reasonably good. At least 6 cubs born in 1980 were successfully recruited into the population. The 3 cub groups shown for 1981 to 1983 (Table 5) are not comparable since there are missing year classes. The proportion of cubs (C, 1, and 2 years) in the Kananaskis population was 33.3%, indicating it to be more productive than the Berland, Swan Hills, and Jasper populations which had 22.5, 20.8, and 4% cubs, respectively. The latter 2 would be somewhat higher if they had included 2-year-olds in the cub group as do the Kananaskis and Berland figures.

Like sex ratios, age ratios are difficult to compare meaningfully with those of other studies because of the tremendous variation in what, exactly, is being reported. It is also recognized that a particular age structure can arise from a variety of situations and, as such, is prone to misinterpretation.

There is little significance in the relative size of individual year classes shown in Fig. 2. Data are too scanty to provide an accurate age profile of the population, but they do show the minimum number of grizzlies born each year. Even this small sample of 24 bears had individuals born in all but 4 years (1969, 1970, 1972, and 1975) between 1966 and 1980.

4.3 Mortality

Table 6 shows that 10 of 25 captured grizzlies (40%) were known to have died by December 1987. However, not all were in the sample group (i.e., marked) for all 8 years (1980–87); some bears were not marked until 1983 and 3 others died during the marking period, 1 each in 1980, 1981, and 1982.

Annual mortality of marked bears varied from 0–16.7% for females and 0–18.7% for males over the 7 years for which the rate could be calculated (Table 7). The average from 1981–1987 was 3.4% for females and 9.8% for males.

The combined male and female mortality rate for marked bears was biased because males had a higher rate and outnumbered females 3:1 in the sample. If the sex-specific mortality rates were accurate, and if each sex was represented equally in the sample being monitored, (as it should have been if the sex ratio was 1:1), then the overall mortality rate would be 6.6%/year. It might even be lower because females had a lower mortality rate and likely outnumbered males in the population.

These figures represent known mortality, and they are based on the assumption that 15 bears (5 female, 10 male) remained alive through 1987. Natural mortality in prime adult grizzlies is generally

Table 3. Records of capture, recapture, relocation, and death of grizzlies marked in Kananaskis Country.

Bear number	Sex	Age	Date marked	Times		Date of		Cause and location of death
				Re-captured	Re-located	Last observation	Death	
H1	M	12	13 Aug 80	2	37	2 Aug 84	9 Sep 87	Shot in Alta[b]
H2	M	4	14 Aug 80	0	0	(no radio)		
H3	M	9	28 Aug 80	0	1	(no radio)	28 Apr 84	Shot in Alta[a]
H5	M	14	5 Sep 80	1	0	(no radio)		
S1	M	4	17 Jun 81	1	71	16 Aug 84		
H6	M	5	3 Jul 81	0	11		17 Sep 81	Shot in Alta[b]
H7	M	15	9 Aug 81	2	32		6 Jun 82	Shot in B.C.[a]
H10	M	3	26 Jun 82	1	22	6 Jun 83	8 May 86	Shot in B.C.[a]
H14	M	5	5 Aug 82	2	35	17 Jun 84		
K1	M	8	27 Jun 82	0	18	13 May 83	5 Jun 84	Shot in B.C.[a]
H15	M	15	26 May 83	0	7	29 Jul 83		
H16	M	3	4 Jun 83	3	21	18 Nov 83		
H17	M	6	13 Jun 83	0	9	27 Aug 83	28 Apr 86	Shot in Alta[a]
H18	M	3	30 Jun 83	0	20	1 Dec 83		
H19	M	7	22 Jul 83	1	15	1 Dec 83		
H21	M	5	24 Jul 83	1	17	16 Dec 83	28 Apr 84	Shot in Alta[a]
S2	M	3	30 May 83	0	23	9 Aug 84		
S3	M	3	15 Jun 83	0	13	1 Dec 83		
H4	F	6	29 Aug 80	0	0		29 Aug 80	Trap Death
H8	F	4	19 Aug 81	0	12	25 Nov 82		
H9	F	14	13 Sep 81	3	77	16 Sep 84		
H11	F	2	8 Jul 82	4	54	16 Sep 84		
H12	F	2	11 Jul 82	1	52	16 Sep 84		
H13	F	6	15 Jul 82	0	48	16 Sep 84		
H20	F	10	24 Jul 83	0	26	16 Sep 84	20 Sep 85	Shot in Alta[b]

[a] Legal harvest.

[b] Self-defensive action.

Table 4. Sex and age distribution of 24 grizzly bears[a] captured in Kananaskis Country and all backdated to 1980.

Age	Males	Females	Total	Identification of bears in age category
Cubs				
C	4	2	6	H11, 12, 16, 18, S2, 3
1	1		1	H10
2	1		1	H21
Subadults				
3	3		3	H14, 17, S1
4	3	1	4	H2, 6, 13, 19
5				
Adults				
6	1	1	2	H4, K1
7		1	1	H20
8				
9	1		1	H3
10				
11				
12	2		2	H1, 15
13		1	1	H9
14	2		2	H5, 7
Subtotals				
Cubs (C, 1, and 2 years)	6	2	8	
Subadults (3, 4, and 5 years)	6	1	7	
Adults (6 + years)	6	3	9	
Total	18	6	24	

[a] The Montana nuisance bear (H8) was excluded from this analysis.

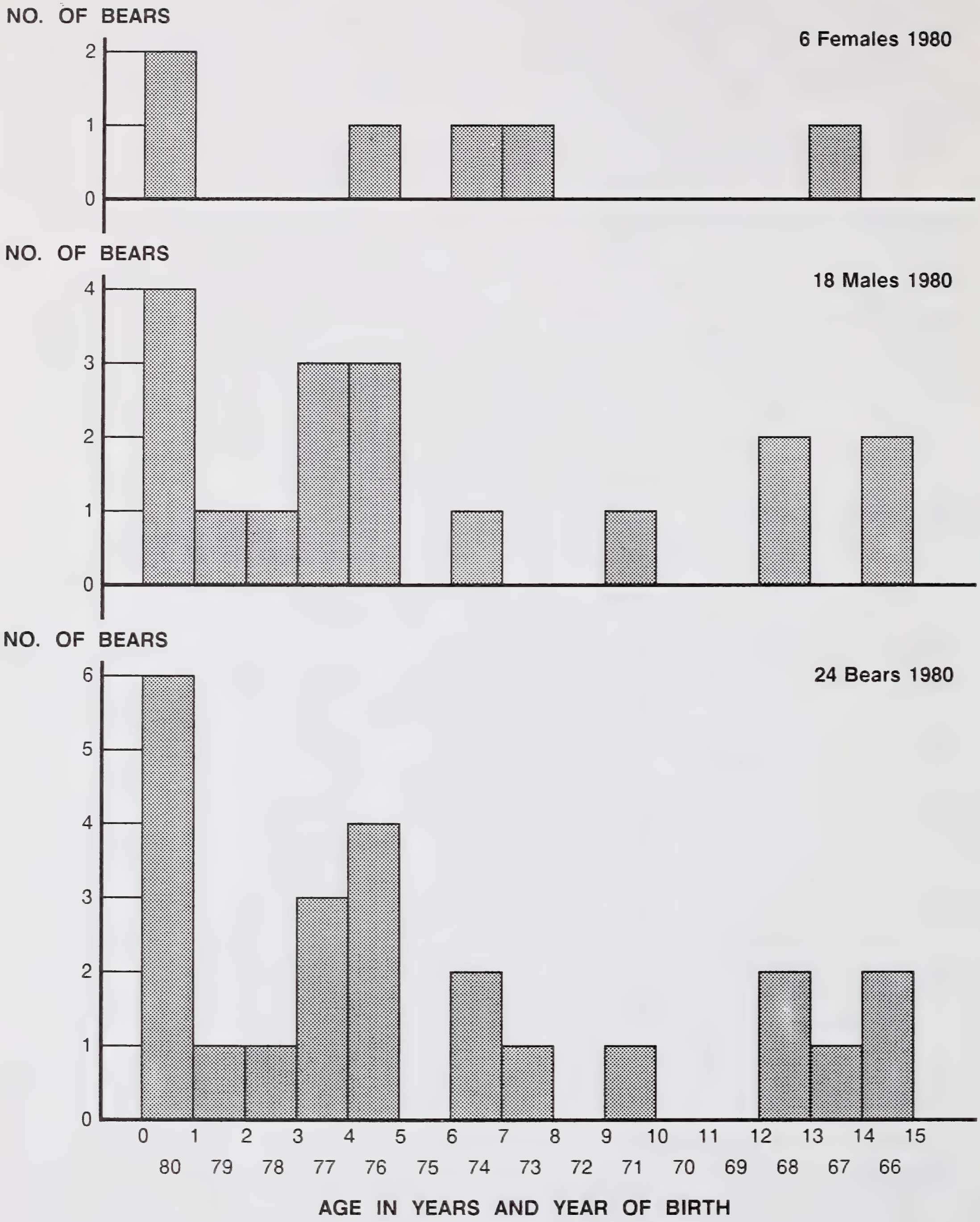

Fig. 2. Age structure of 24 captured grizzlies, all backdated to 1980.

Table 5. The changes in sex and age structure of 24 captured grizzlies because of aging and mortalities between 1980 and 1983.

Age group	1980			1981[b]			1982[c]			1983[d]			Average		Ratio
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	M:F
Cubs[a] (C, 1, and 2 years)	6	2	8	5	2	7	4	2	6				3.75	1.5	2.5:1
Subadults (3,4, and 5 years)	6	1	7	7	1	8	5	0	5	6	2	8	6	1	6:1
Adults (6 + years)	6	3	9	6	2	8	8	3	11	10	3	13	7.5	2.75	2.7:1
Total	18	6	24	18	5	23	17	5	22	16	5	21	17.25	5.25	3.3:1
Ratio (Adult: Subadult)													1.25:1	2.75:1	

[a] The cub group includes cubs, yearlings, and 2-year-olds in 1980; yearlings and 2 year olds in 1981; only 2-year-olds in 1982; and is no longer represented in 1983.

[b] 1981 – 1 adult female died at age 6 in 1980.

[c] 1982 – 1 subadult male died at age 5 in 1981.

[d] 1983 – 1 adult male died at age 16 in 1982.

Table 6. Fate to December 1987 of 25 grizzlies marked in Kananaskis Country between 1980 and 1983.

	Number of bears			Cause of death			
	Marked	Alive	Dead	Legal hunting		Self defense	Research
				Alta.	B.C.		
Males	18	10	8	3	3	2	0
Females	7	5	2	0	0	1	1[a]
Total	25	15	10	3	3	3	1

[a] This bear is removed from most calculations and discussions of mortality, since her death was due to study procedure and not representative of normal mortality in the population.

Table 7. Known annual mortality rates of Kananaskis Country grizzly bears that were marked and thought to be in the population for the full year or until death.

Year monitored	Number of marked bears						Mortality rate %	
	Present on 1 Jan			Dead by 31 Dec				
	Female	Male	Total	Female	Male	Total	Female	Male
1981	0	4	4	0	0	0	0	0
1982	2	6	8	0	1	1	0	16.7
1983	5	8	13	0	0	0	0	0
1984	6	16	22	0	3	3	0	18.7
1985	6	13	19	1	0	1	16.7	0
1986	5	13	18	0	2	2	0	15.4
1987	5	11	16	0	1	1	0	9.1
All	29	71	100	1	7	8	3.4	9.8

low (Craighead et al. 1974; Sidorowicz and Gilbert 1981; Nagy et al. 1983*b*; Knight and Eberhardt 1987), and all of these 15 were at least 4 years old when radio monitoring ceased in 1984. By 1987, however, the 3 oldest bears would be 19, 20, and 21 years of age and nearing the ends of their lives. Since telemetry contact terminated after 1984, some mortality, especially natural, could have gone unnoticed. If so, these figures would underestimate actual mortality. No natural mortality was recorded.

No cubs-of-the-year nor yearlings were marked; these figures, therefore, do not account for any mortality in grizzlies under 2 years of age. Although thought to be greater during early independence, mortality of young is generally believed to be low while they are accompanied by mothers (Craighead et al. 1974; Knight and Eberhardt 1985). However, Reynolds and Hechtel (1982) suggested that mortality of young could be quite high, and Nagy et al. (1983*b*) found that 75% of natural mortality occurred in cubs-of-the-year, the remaining 25% in yearlings. If annual mortality in young grizzlies (0–2 years) was greater than 3.4% in females or 9.8% in males, the overall mortality rate for that sex would be higher.

Fortunately, grizzly mortality in Kananaskis Country was focused on males, 44% of which had died through 1987. Except for 1 research death, only 1 female (16.7%) had died over the same period. However, only 6 females in a relatively small area were monitored, so the result should be viewed with caution. If the female mortality rate is representative and remains low, the population should have the potential to expand and such expansion may be aided by the removal of older males. There is considerable evidence that adult males exert direct and indirect pressure reducing the survivorship of younger bears (Kemp 1976; Bunnell and Tait 1981; McCullough 1981; Sidorowicz and Gilbert 1981), although the opposite has also been suggested (LeCount 1987).

The causes for all 10 known mortalities are shown in Table 6. Clearly, the primary cause of death for these bears (2 years and older) was man. Six were shot legally during hunting seasons, 3 in Alberta and 3 in British Columbia. Three of the remaining 4 were shot in apparent self-defensive actions, while the last bear was shot as a result of a mishap during trapping activities.

Hunting seasons for grizzlies in Alberta south of Kananaskis Country reopened in 1982 and caused

1/3 of the mortality of the marked bears. Seasons in Kananaskis Country reopened in 1987, but only 1 unmarked bear was killed. Hunting regulations designed for protection of females appeared effective, as no marked females had died as a result of these seasons. Restrictions to protect females included closing an early spring season by mid-May and a closed season for females accompanied by cubs or yearlings.

If representative, the total mortality indicated by these data is not excessive. Grizzlies can sustain overall mortality of 10–13%/year depending on the population's reproductive rate (Bunnell and Tait 1981; McCullough 1981; Sidorowicz and Gilbert 1981). A maximum of 10–11% mortality would be a reasonable and conservative target for the Kananaskis population.

As indicated by the deaths of 9 marked bears, only 1/3 of the population's mortality occurred inside Kananaskis Country — all 3 in the Highwood Wildlife Management Unit (WMU 404) where the bears were marked. Throughout Kananaskis Country, only 2 additional bears (both unmarked) have died since 1980 — 1 legally in 1987 and 1 illegally in 1981, both in WMU 408 (Gunson and Treichel 1987). Thus a total of 5 grizzlies (marked and unmarked and excluding the research death) were known to have died in Kananaskis Country over the 8 years from 1980–1987, an average of 0.625 bears/year. Based on a population estimate of 50 bears (see Population Density), the mortality rate of grizzly bears within Kananaskis Country was only 1.25%/year.

Because of their large home ranges, these grizzlies, especially males, were subject to additional and greater mortality beyond Kananaskis Country. Two-thirds of marked bear deaths (6 out of 9) occurred beyond Kananaskis Country, 3 in WMU 402 (immediately south of Kananaskis Country) and 3 in British Columbia. In WMU 402, 7 unmarked and 3 marked grizzlies have died since 1980. This was an average of 1.25 mortalities/year, double the number within Kananaskis Country. However, marked bears formed a smaller percentage of total mortality in WMU 402, only 30% compared to 60% in Kananaskis Country. Similar differences would be expected just west of Kananaskis Country in British Columbia.

The causes of marked bear mortalities also differed within and outside of Kananaskis Country. Within, all 3 mortalities resulted from self-defensive incidents. Outside, all 6 mortalities were legal sporting kills and none was killed in self defense. The lack of sporting kills in Kananaskis Country can be explained by the hunting season which remained closed until spring 1987; however, the absence of self-defensive kills outside of Kananaskis Country appears partly due to chance. Although no marked bears died in self-defensive or illegal situations in WMU 402, 4 unmarked bears were so killed since 1980 if all known mortalities in that unit are considered (Gunson and Treichel 1987). Since the grizzly population in WMU 402 was only about 1/3 the 50 estimated for Kananaskis Country, these data suggest that the combined self-defensive and illegal kill rate in WMU 402 was actually greater than in Kananaskis Country.

4.4 Distribution

Grizzly bears occurred throughout the study area and generally throughout the contiguously forested area of southwestern Alberta. However, in the early 1980s, they were common west of the front ranges in more remote areas that had the least impact from human activity; they were uncommon, perhaps transient, in the foothills east of the front ranges near settled ranchlands. This was substantiated by comparing relative trapping success in the Highwood and Sheep areas (Table 1). However, grizzly captures in the Sheep area, along with increasing observations of grizzlies and sign (both by Fish and Wildlife staff and the trapping crew [Mamo et al. 1984]) east of the front ranges, suggested that the grizzly population was again expanding into the foothills.

As would be expected from such a mobile species, movements of these grizzlies took them well beyond Kananaskis Country. Clearly they were an interprovincial resource with most spending some time west of the Continental Divide in British Columbia.

4.4.1 Home Ranges

The distribution of radio-collared grizzlies captured in the small trapping areas is described generally by their home ranges, shown collectively (all bears, all years) for males and females in Fig. 3. The multi-annual home ranges for each of the 5 radio-collared females are shown in Fig. 4. Distribution is given in more detail by the individual home ranges shown in Figs. 5–17 for males and Figs. 18–21 for females (Appendix).

Table 8 gives the number of individual locations used in outlining annual home ranges for each bear as well as the dates between which the locations were obtained. Four male home ranges in 1983

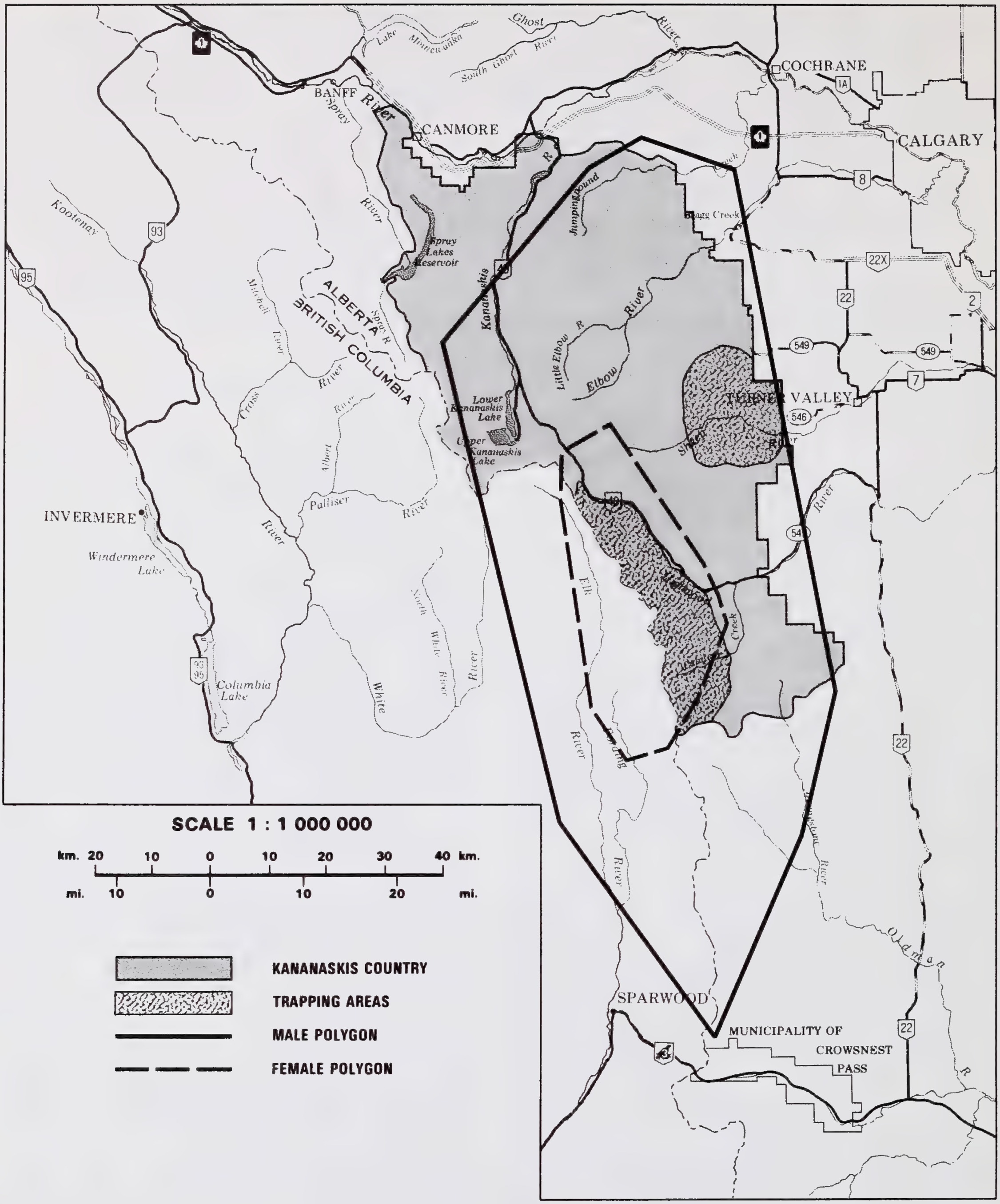

Fig. 3. Multi-annual minimum area home range polygons based on 313 locations of 14 male and 236 locations of 5 female grizzly bears from 1981–1984.

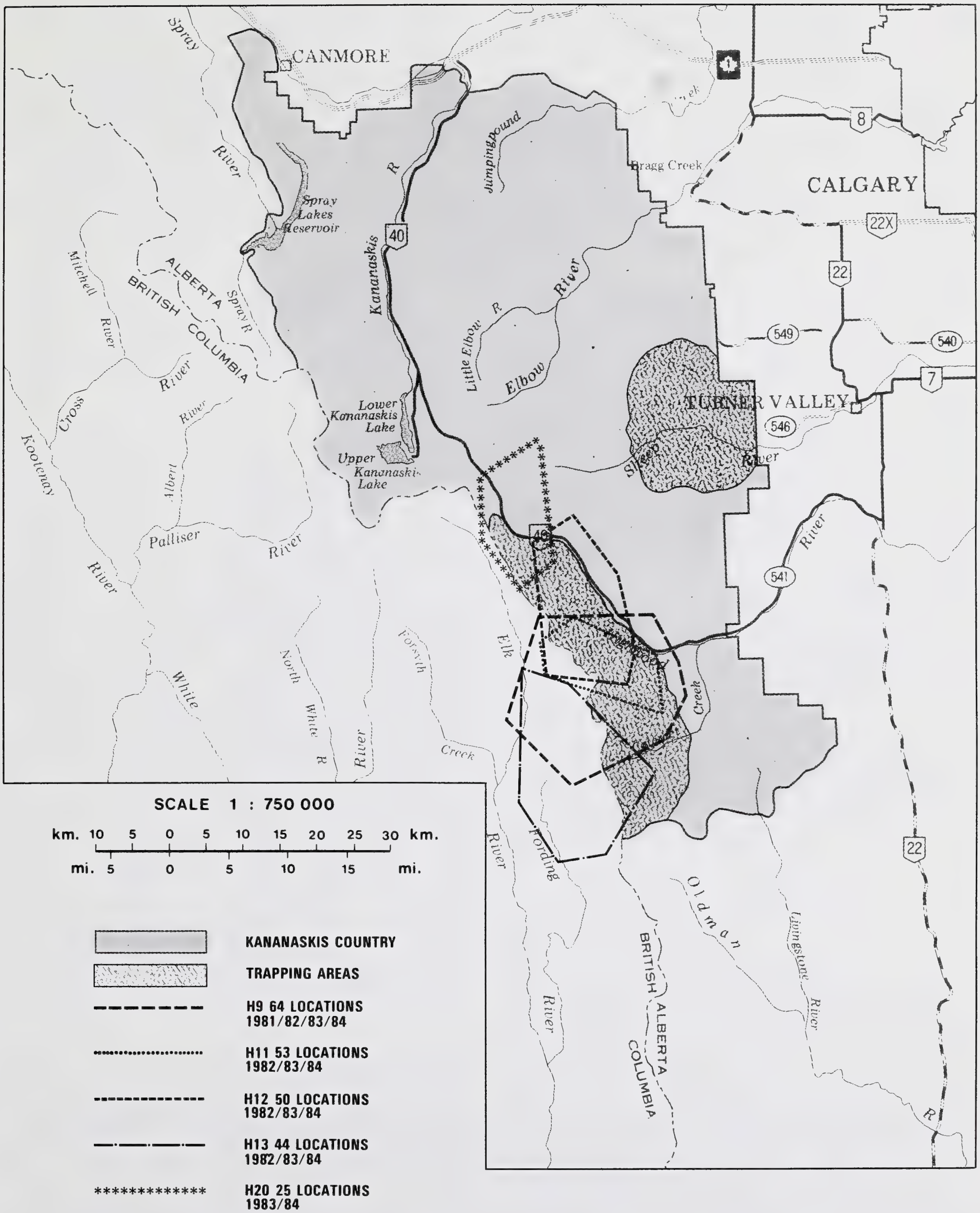

Fig. 4. Multi-annual minimum area home range polygons (convex) for each of 5 female grizzly bears.

Table 8. The number of grizzly bear locations (*N*) and the dates between which they were recorded each year.

Bear		1981		1982		1983		1984	
No.	Sex	*N*	Dates	*N*	Dates	*N*	Dates	*N*[a]	Dates
K1	M	0		16	Jun 27-Nov 25	3	Apr 1-May 13	0	
S1	M	13	Jun 17-Dec 21	27	Mar 22-Dec 2	21	Apr 1-Dec 1	6	Jun 11-Aug 16
S2	M	0		0		18	May 30-Dec 1	4	Jul 11-Aug 9
S3	M	0		0		12	Jun 15-Dec 1	0	
H1	M	0		15	Jul 26-Dec 2	15	Apr 6-Oct 24	6[a]	Jun 17-Aug 22
H6	M	11	Jul 3-Sep 17	0		0		0	
H7	M	20	Aug 9-Dec 21	11	Apr 1-Jun 6	0		0	
H10	M	0		17	Jun 26-Dec 2	5	Apr 1-Jun 6	0	
H14	M	0		15	Aug 5-Dec 2	17	Apr 6-Dec 1	3	Jun 11-Jun 17
H15	M	0		0		6	May 26-Jul 29	0	
H16	M	0		0		21	Jun 4-Nov 18	0	
H17	M	0		0		9	Jun 13-Aug 27	0	
H18	M	0		0		16	Jun 30-Dec 1	5	Jun 17-Aug 16
H19	M	0		0		14	Jul 22-Dec 1	0	
H21	M	0		0		15	Jul 24-Dec 16	0	
H9	F	9	Sep 13-Dec 21	26	Apr 1-Nov 25	20	Apr 1-Dec 1	13	Jun 11-Sep 16
H11	F	0		17	Jul 8-Dec 2	25	Apr 1-Dec 1	13	Jun 11-Sep 16
H12	F	0		16	Jul 11-Dec 2	23	Apr 1-Dec 1	13	Jun 11-Sep 16
H13	F	0		12	Jul 15-Nov 25	21	Apr 1-Dec 1	13	Jun 11-Sep 16
H20	F	0		0		13	Jul 24- Dec 1	13	Jun 11-Sep 16

[a] All 1984 numbers (except H1) include an Apr 1 den site (located in 1983) that is not included in the dates but is used in home range maps and area calculations.

(K1, H10, H15, H17) and all in 1984 were based on less than 10 locations. Because of the large home ranges and long movements of male grizzlies, limited budgets would not permit regular location of these bears. Because female home ranges were smaller and female locations more predictable, all but one of their home ranges were based on more than 10 locations. Further budget reduction in 1984 forced the abandonment of male telemetry and forced the focusing of effort on females which could be found more efficiently. Subsequently, males were recorded only when they approached the female home ranges and could be located without additional cost.

Many home ranges lack locations in all months and, hence, are not complete. Only 3 males were monitored for more than 2 years, and because most males were not collared until mid-summer, their home ranges lack adequate spring (April and May) locations. Only 4 annual home ranges (S1's in 1982 and 1983, H1's and H14's in 1983) have locations in all months and are considered complete. On a multi-annual basis, 3 others (K1's, H7's, and H10's) represent most months, although H7's has no July locations. Four of the 5 annual home ranges of females were complete in 1983. The home range of H9 was also complete in 1982, but there were no April or May locations for H20 in either year it was monitored.

Home ranges of the 15 males tend to be long and narrow, with the long axes paralleling the mountain ranges and major valleys. Home ranges of the 5 females are more similar in length and width and do not have the obvious orientation along the mountain ranges.

Annual home ranges for males vary from 63–1407 km^2 (Table 9), with smaller ranges generally calculated from fewer locations representing less than the full year. The 4 male annual home ranges containing observations from throughout the active period vary from 902–1407 km^2, and average 1183 km^2. The remainder are not included in the average, since they represent both varied and shorter time spans and are not complete annual ranges.

Ranging from 206–2111 km^2, the multi-annual home ranges of most male bears are considerably larger than their annual ones (Table 9). Those containing locations from all months of the active period have the same size-range, but they average only 1026 km^2 because several smaller ranges are included. These data, along with Figs. 5–17, indicate that male grizzlies may use substantially different, though generally adjacent or partly overlapping, home ranges from one year to the next. These Figs. also indicate substantial overlap in the home ranges of different bears. Similar overlap has been found in other grizzly bear studies (Nagy et al. 1983*a*,*b*; Servheen 1983).

As found in studies elsewhere (Canfield and Harting 1987), female home ranges (Table 10) are much smaller than male ones. Home ranges of the 5 females vary from 33–345 km^2. Only 5 annual home ranges contain locations from throughout the active period. They vary from 91–345 km^2 and average 179 km^2 (Table 10). Other home ranges are not included in the average because they do not represent complete annual home ranges. The largest and smallest are both home ranges of H9 and presumably reflect, in part, her reproductive status: estrous in 1982, and with new young in 1983 when her home range was greatly restricted. Servheen (1983) reported the opposite situation in which a female expanded her range over 2-fold when with cubs.

As with males, the multi-annual home ranges of females are substantially larger than their annual ones, and they vary from 131–387 km^2. The average size of those that include locations from all months of the active period during at least one year is 266 km^2.

Home ranges depicted by the minimum area polygon method do not necessarily identify ecologically significant areas, like dens and productive feeding sites, around which actual bear use is highly concentrated. Productive feeding site locations vary from season to season, and, consequently, bears move to optimize their feeding opportunities. Thus, the most important parts of the home ranges may be den sites and seasonal feeding areas, all of which may be separated by substantial distance. The minimum area polygon therefore appears to exaggerate considerably the area actually used by grizzly bears. This is particularly true for males that exhibit extreme movements, perhaps related to occasional exploration or the search for estrous females. It outlines the overall range used, although this range is not used uniformly — indeed, much of it may not be used at all.

Further analyses of these home range data were done by Wielgus (1986), especially for the females. His work describes in detail the use of various habitat components within the home range on a seasonal basis.

4.5 Population Estimate

4.5.1 Direct Observation

Direct observation was of limited effectiveness in this situation where grizzly bears were seldom seen. Nevertheless, trapping produced 25 different grizzlies, all of which would have been alive in 1980 when trapping started. One of these, female H8, was a Montana nuisance bear that moved quickly and steadily out of the study area. Last located south of Highway 3 (Fig. 1), it was obviously a transient bear and was not included in the population estimates. Of the remaining 24 bears, 19 were known and 21 were thought to be still alive in 1983.

In addition to these marked bears, 3 adult females were known to have home ranges north of the trapping areas — 1 each in the upper Elbow,

Table 9. Home range areas (km^2) of radio-collared male grizzlies determined by the minimum convex polygon method and based on annual and multi-annual locations (*N*).

Bear number	1981		1982		1983		1984		All years	
	N	Area	*N*	Area	*N*	Area	*N*	Area	*N*[a]	Area
K1			16	437	3	170			18	712[b]
S1	13	821	27	1407[b]	21	1176[b]	6	429	64	2111[b]
S2					18	598	4	232	21	1141
S3					12	472				
H1			15	444	15	1248[b]	6	190	35	1703[b]
H6	11	104								
H7	20	63	11	79					30	206[b]
H10			17	444	5	175			21	521[b]
H14			15	221	17	902[b]	3	103	34	902[b]
H15					6	102				
H16					21	683				
H17					9	700				
H18					16	670	5	1055	20	1416
H19					14	119				
H21					15	1274				
Total	44		101		172		24		243	

[a] Multi-annual *N* is not the total of annual *N*'s because den sites used as locations in the fall of one year and spring of the next are counted only once in multi-annual ranges.

[b] Home ranges which include locations from throughout the active period.

Burstal, and Wind Creek areas. Each produced 2 young between 1982 and 1984. Although their ages were not verified, 4 cubs were likely born in 1983; the other two not until 1984. These bears were residents of the general study area, but their home ranges were likely outside the effective trapping area for females.

Direct observation yielded a known minimum of 27 (24 marked, 3 unmarked) grizzly bears in 1980 and 26 (19 marked, 3 unmarked plus 4 young) in 1983. These minimums did not represent the total population. Since only a small part of the area was trapped, especially those females residing more than a few kilometres beyond the trapping area would have had little chance of capture (Figs. 3 and 4). During the last major trapping effort in 1983, 9 of 11 captured bears were unmarked, suggesting that the total population was considerably larger than the 21 marked animals thought to be in the population at that time.

4.5.2 Capture-Recapture

Seven estimates of the male population (Table 11) ranged from 10–40 bears (3 years and older) and yielded a mean estimate of 24.1, with the 95% confidence interval from 16–34. Because of

Table 10. Home range areas (km^2) of radio-collared female grizzlies determined by the minimum convex polygon method and based on annual and multi-annual locations (*N*).

	1981		1982		1983		1984		All years	
Bear number	*N*	Area	*N*	Area	*N*	Area	*N*	Area	*N*[a]	Area
H9	9	33	26	345[b]	20	91[b]	13	105	64	387[b]
H11			17	72	25	128[b]	13	55	53	131[b]
H12			16	83	23	150[b]	13	90	50	228[b]
H13			12	36	21	180[b]	13	167	44	317[b]
H20					13	46	13	112	25	145
Total	9		71		102		65		236	

[a] Multi-annual *N* is not the total of annual *N*'s because den sites used as locations in the fall of one year and spring of the next are counted only once in multi-annual ranges.

[b] Home ranges which include locations from throughout the active period.

inadequate sample size, only 3 estimates of the female population could be calculated (Table 12). They ranged from 3–7.5 bears (3 years and older) and averaged 5.2 (95% confidence limits 5–11). The initial lower confidence limits for both males and females were considered inadmissible since they were below the numbers of bears actually observed; therefore, they were raised to the observed number as suggested by White et al. (1982).

Because the various estimates applied to different sampling periods, and because the populations likely varied from period to period, 24.1 males were viewed as an average population over the 3-year time span involved. The female estimate of 5.2 was an average over the 2 years of 1982–83. This contributed to the rather wide confidence intervals, but the small sample sizes, especially for female estimates, were major shortcomings as well.

The capture-recapture technique estimates the male and female populations of only those bears whose home ranges contacted the traps. The male estimate therefore applies to a much larger area than does the female estimate. The overall home ranges of males and females (Fig. 3) suggest a 6-fold difference — 6286 compared to 1033 km^2.

In order to estimate the total population, it is necessary to adjust the male estimate to account for the females and young that resided within the area occupied by the males. Many of these females and young had no chance of capture because their home ranges did not contact the trapline. Their numbers can be estimated from other data.

Based on the average age ratio of the marked male bears of 1.25 adults/subadult (Table 5), the estimated 24.1 male grizzlies consisted of about 13.4 adults and 10.7 subadults (3-, 4-, and 5-year-olds). Sex ratios in grizzly bear populations approximate 1:1, with some evidence that they favor males in cubs but gradually shift to favor females in the adult category. In hunted populations, the adult sex ratio may be skewed substantially towards females because of hunter selectivity for the larger males and laws protecting females. In this study, 6 of the 9 known mortalities of marked bears were males killed legally in hunting seasons (Table 6). Thus, if the subadult sex ratio approximated 1:1, there should also have been 10.7 subadult females in the population. Assuming slight skewing to 0.8 males/female in the adult group, there should have been 16.8 adult females in this population which was subject to hunting in parts of British Columbia and Alberta.

Female grizzlies produce young about every 3 years in most populations (Canfield and Harting 1987). If these 16.8 adult females produce every 4 years, then 75% would have young (cubs,

Table 11. Modified Petersen estimates of the number of male grizzly bears (3 years and older) in the Kananaskis study population.

Period of		Recapture data			Population estimate[d]	SD[d]
Marking	Sampling	M[a]	n[b]	m[c]		
1980	1981	4	3	0	20	12.25
1980	1981/82	4	6	1	17.5	8.54
1980	1981/82/83	4	13	1	35	18.71
1980/81	1982	5	4	2	10	3.16
1980/81	1982/83	5	12	2	26	11.40
1980/81/82	1983	7	9	1	40	20.66
1981/82	1983	3	9	1	20	10.33
Average					24.1	
95% C L (White et al. 1982)					16–34	

[a] M is the number of bears marked during the marking period and in the population over the sampling period.

[b] n is the total number of bears captured during the sampling period.

[c] m is the number of bears captured during the sampling period that had been previously marked.

[d] Population estimate and standard deviation calculated by equations

$$N = \frac{(M+1)(n+1)}{m+1} \quad \text{and} \quad SD = \sqrt{\frac{N^2(n-m)}{(n+1)(m+2)}} \quad \text{(Ricker 1975)}$$

yearlings, or 2-year-olds) in any 1 year. At 2 young/litter, there would be 25.2 young grizzlies. Based on the described assumptions, the grizzly population estimated by this process would therefore total 77 bears (24.1 males, 27.5 females, and 25.2 young).

Similarly, the estimate of 5.2 females had to be adjusted to account for males and young. At an adult to subadult ratio of 2.75:1 (Table 5), the 5.2 females would consist of 3.8 adults and 1.4 subadults. There would also be 1.4 subadult males and 3 adult males based on male:female ratios of 1:1 for subadults and 0.8:1 for adults. Again, if 75% of the 3.8 adult females had 2 young each, there would be 5.7 young. The total population in the area of the female estimate would be 15 bears (5.2 females, 4.4 males, and 5.7 young).

4.6 Population Density

The multi-annual home range polygon for all bears (Fig. 3) covers 6286 km^2, and the marked bears were never located outside it. Applying the population estimate of 77 bears to this area yields a density of 1 bear/82 km^2. The multi-annual home range polygon for females (Fig. 3) covers 1033 km^2, and marked females were never located outside it. Applying the population estimate of 15 bears to this area yields a density of 1 bear/69 km^2.

These are likely conservative figures. Although these polygons seemed to enclose the respective male and female study populations (those bears whose home ranges contacted the traps), study bears were not the only ones using them. Many bears north, west, and south of these areas would

Table 12. Modified Petersen estimates of the number of female grizzly bears (3 years and older) in the Kananaskis study population.

Period of		Recapture data			Population estimate[d]	SD[d]
Marking	Sampling	M[a]	n[b]	m[c]		
1980	1981	0	1	0	NSD[e]	
1980	1981/82	0	2	0	NSD	
1980	1981/82/83	0	6	0	NSD	
1980/81	1982	1	2	1	3	1.22
1980/81	1982/83	1	4	1	5	2.74
1980/81/82	1983	4	2	1	7.5	3.06
Average					5.2	
95% CL (White et al. 1982)					5–11	

[a] M is the number of bears marked during the marking period and in the population over the sampling period.

[b] n is the total number of bears captured during the sampling period.

[c] m is the number of bears captured during the sampling period that had been previously marked.

[d] Population estimate and standard deviation calculated by equations

$$N = \frac{(M+1)(n+1)}{m+1} \quad \text{and} \quad SD = \sqrt{\frac{N^2(n-m)}{(n+1)(m+2)}} \quad \text{(Ricker 1975)}$$

[e] NSD means not sufficient data.

have had home ranges overlapping the polygons but not reaching the trapping area.

Bear density in the polygons would also have been underestimated because of the effect of home range location on capture probabilities. Bears with home ranges centered on, and overlapped substantially by, the trapping area have a greater probability of capture and being marked than do bears with home ranges that are near the polygon peripheries and that are overlapped minimally by the trapping area. Thus the ratio estimators (ratios of marked to unmarked bears in the recapture samples from the trapping area) for both males and females indicate higher percentages of bears marked than would have been indicated if recapture sampling had been distributed equally throughout the polygons. This underestimation is likely substantial as indicated by ratios of marked to unmarked bears in kill records since 1980 from WMUs 404 and 402. In 404, which enclosed the trapping area, 3 out of 3 mortalities were marked. In adjacent 402, which included more area near the polygon periphery, only 3 out of 10 mortalities were marked.

Furthermore, the Chapman model has negative bias with small samples (recaptured marks less than 4) (Ricker 1975). This bias is most severe in the female estimate, indicating that the population in the female polygon is more severely underestimated than that in the male polygon. It appears, therefore, that these population estimates are minimal.

The greater population density of 1/69 km2 is reasonable for the female polygon (Fig. 3) which overlapped high quality grizzly habitat straddling the Continental Divide. It is a density that, for a few years, could be judiciously projected to approximate grizzly numbers in good habitats in this region along the Continental Divide and west of the Fisher, Opal, Highwood, and Livingstone mountain ranges. Further projection of this density in space or time would be risky.

The population density of 1/82 km^2 applies to the multi-annual male polygon. This polygon included the good habitat in the female polygon. It also included more area of alienated habitat like that in the third of its area lying east of the front ranges where grizzlies were still uncommon. This density is an average over a 6-fold larger area and is more appropriate for general application. Based on this average density (1/82 km^2), the 4160 km^2 of Kananaskis Country would have a grizzly population of at least 50 bears. As the population is geographically open, however, many other grizzlies use Kananaskis Country at times. Conversely, most of the 50 bears use other areas as well.

As discussed above, the calculated densities for both the male and female polygons would underestimate the actual populations, likely to a substantial extent. However, the relationship between the densities is logical and both are reasonable as minimums.

Density comparison between studies was only of gross value because differences in techniques and circumstances influenced the estimates dramatically. Nevertheless, density provided a common measure, and reported estimates were always reasonable in the authors' opinions. Harting (1987*b*) lists densities from most North American studies. They range from 1.52 km^2/bear in southern coastal Alaska, to 211–262 km^2/bear on arctic barren grounds near Tuktoyaktuk, Northwest Territories.

Intermediate densities have generally been found in Alberta populations. Although more exploited in recent years, Kananaskis area grizzlies have been relatively protected, at least in the Alberta portion of their range where hunting seasons were closed after spring 1970 until 1982, 1987 in Kananaskis Country itself. By 1983, this apparently expanding grizzly population had reached densities (69–82 km^2/bear) slightly greater than those reported by Russell et al. (1979) for similar mountain habitat in Banff (70–120 km^2/bear) and Jasper (85–102 km^2/bear) national parks. The density was also greater than the 104–139 km^2/bear found by Nagy and Russell (1978) in Swan Hills, a boreal forest environment east of the Rocky Mountains. Nagy and Russell (1978) believed that population to be declining because of resource development conflicts and resultant excessive exploitation. Nagy et al. (1988) found an exceptionally low density of 217 km^2/bear for a boreal uplands population in the Berland area. This is the lowest density found in Alberta and one of the lowest recorded for North America. They believed that population to be declining because of habitat deterioration, resource development activities, and excessive mortality.

The Kananaskis density is comparable to those reported for the Mackenzie Mountains (86 km^2/bear) by Miller et al. (1982) and for Yellowstone Park (80 km^2/bear) by Craighead and Mitchell (1982). Higher densities have been reported for other interior mountain populations: 16 km^2/bear in southeastern British Columbia (McLellan no date); 18 km^2/bear in Glacier Park, British Columbia (Mundy and Flook 1973); 21 km^2/bear in Glacier Park, Montana (Martinka 1974); and 27 km^2/bear in southwestern Yukon (Pearson 1975).

The population in the Kananaskis area may yet attain higher density, although a major increase would be surprising since current density may already exceed those of Jasper, Banff, and Yellowstone national parks. Compared to other designations, park areas often provide greater habitat security and protection from resource development and agricultural activity. In spite of park status, however, park bears usually suffer substantial man-caused mortality resulting largely from either management actions within the park or a variety of causes outside. Because of their huge home ranges, few grizzlies remain always within the protected areas provided by even the larger parks.

The high densities in Glacier Park, British Columbia, Glacier Park, Montana, and in southeastern British Columbia were likely due to highly productive habitats. Such densities are not likely to be reached by Kananaskis area grizzlies, especially with the resource development and human recreational pressures faced by this population, both in Alberta and British Columbia.

Few, if any, grizzly populations are unhunted and available for comparison with hunted ones. Although many areas (e.g., parks) are not hunted, most grizzly populations are. Because of their large home ranges, most male grizzlies eventually move onto lands open to hunting. Even populations in large, unhunted areas such as Jasper (Russell et al. 1979) and Yellowstone (Craighead and Mitchell 1982) national parks have been substantially harvested by sport hunting seasons on surrounding lands. However, the effect of legal sport hunting on grizzly density seems relevant only as it relates to total mortality. It is total mortality, whatever its components, that must be controlled to maintain an appropriate population density.

Sport harvest is relatively easy to monitor and control. If properly regulated, it takes part of the annual recruitment with little impact on average, long-term density. In populations where excessive mortality causes bear numbers to decline unacceptably, reduction of that mortality is essential. Sport harvest is often the easiest and quickest to limit; however, it would be preferable to reduce illegal kills, self-defensive kills, and bear removals for problem wildlife or other management reasons.

The overall density of the Kananaskis area population appears reasonable and compares favorably with others, but it varies greatly between locales. Although the population appears to be expanding in the foothills, this area will likely function as a "grizzly sink" with its lower density attracting subadult bears from more stable and higher density situations west of the front ranges. Thus in spite of continual immigration, grizzly density in the foothills will likely remain low because of high mortality resulting from greater conflicts there with livestock, resource development, and human recreation. An analogous situation was hypothesized by Nagy and Russell (1978) for the Swan Hills area. Maintenance of a lower density in the foothills is probably a desirable situation, particularly if legal sport hunting reduces the need for control of problem grizzlies around livestock, campgrounds, and other developments in this area.

5.0 MANAGEMENT IMPLICATIONS

Some significant implications for management of grizzlies, as well as for human activities and developments, can be identified from the foregoing results. They are based on the recognition that over 700,000 people live adjacent to this grizzly habitat and place heavy demands on it for a variety of often competing uses. Further, they are based on the belief that it is both the public's responsibility and desire that grizzlies remain part of the natural wildlife community in the Kananaskis Country area.

Distribution and home range data show clearly that grizzlies in this area are a resource shared with British Columbia. The welfare of these bears is dependent on development, habitat management, and bear management decisions made by various agencies in both provinces — decisions which should not be made in isolation.

Grizzly mortality within Kananaskis Country is only about 1.25%/year, indicating the population in this area should be expanding given normal production. However, the population is subject to greater mortality outside Kananaskis Country; the known overall mortality rate averages about 6.6%/year, all man-caused. The mortality rate for young grizzlies (under 2 years) was not monitored, and for females it was based on a small sample from a small area. Future work should rectify these deficiencies. With these uncertainties, the 6.6% annual mortality requires continued careful monitoring and appropriate management to ensure it remains at acceptable levels and focused on males. Continued adequate protection for females is essential to ensure their mortality remains low and the population strong.

Sport harvest rate must be carefully controlled since it caused 2/3 of known mortality of marked bears. Cooperation between Alberta and British Columbia is essential since this mortality was divided equally between the two provinces. Sport harvest mortality demonstrates the significance of management decisions in other areas and by other jurisdictions. These bears were harvested even though all were marked in Kananaskis Country, an area closed to grizzly hunting except for a limited season in spring 1987. Not one marked grizzly was killed by sport hunting inside Kananaskis Country.

Since overall mortality of 10–11% would be reasonable for the Kananaskis Country population of 50 bears, limited-entry spring hunting and a harvest of about 2 bears/year should be sustainable in this area where annual mortality now averages only 1.25%. Throughout its range, the population has room for only an additional 4% mortality (assuming normal production) if it is not to decline. Therefore, increased harvest in Kananaskis Country may necessitate a slight reduction outside. Caution is advised since mortality of young has not been documented and natural mortality must exist even though it was not found.

The grizzly population, estimated at 1 bear/82 km^2, has some implications for future control of livestock depredation. In the better remote habitats, depredation control, if necessary, should emphasize adjustments of livestock management practices. For example, livestock should be removed from significant grizzly foraging areas, at least during critical periods. However, if grizzly numbers increase in the foothills near private lands, increased depredation should be expected. Here, its control should emphasize adjustments in bear management, including the current practice of selectively removing offending bears, if reasonable adjustments in livestock management do not solve the problem satisfactorily. Hunting seasons designed to maintain higher densities (at least 1 bear/69 km^2) west of the front ranges but substantially lower ones in the foothills would be reasonable. The actual density goal for the foothills would have to be determined based on acceptable depredation levels.

Most implications for management of people, their developments and activities relate to human safety and to the desire for conservation and maintenance of grizzly populations. The population and distribution data indicate that grizzlies occur potentially anywhere in Kananaskis Country, and their presence is therefore an issue to be considered at all times in plans for human developments and activities. Major facilities or developments attractive to large numbers of people should be minimized in the better and more remote habitats where bear densities reach at least 1 bear/69 km^2. They should be curtailed totally in locally significant areas like McPhail Creek (Wielgus 1986) that attract even greater concentrations of grizzlies. Conscientious avoidance of such habitats will do much to ensure the maintenance of grizzlies and the protection of people.

With the existing grizzly population, the human safety issue will attain greater significance as Kananaskis Country developments attract more people to the area. In addition to concerns associated with major developments, location of trails and management of people in the backcountry must be planned to avoid confrontations with grizzlies (Herrero et al. 1986). Remote or isolated valleys frequented by females with cubs are of great concern (Russell et al. 1979), as are prime food-producing sites. The human safety issue needs to be considered indepth and monitored carefully.

Since 1/3 of known grizzly mortality was caused by self-defensive actions, such actions should be monitored and thoroughly studied to find ways to reduce this mortality. The relationship between hunting and grizzly-human interactions needs to be studied further, since all 3 self-defensive mortalities were caused by people legally hunting other game. Some confrontations and subsequent mortalities could be prevented through appropriate education to help people, perhaps especially hunters, avoid these potentially disastrous situations.

Although Kananaskis Country's wildlife capability is high, its future for wilderness species like the grizzly is precarious. With future growth and intensification of industrial and recreational activity, greater effort and commitment will be required to maintain such species which need room and reasonable freedom from human intrusion.

Because of their proximity to Kananaskis Country, 600,000 Calgarians with their recreational demands pose perhaps the greatest management challenge. The demands and activities of these people must be channelled carefully so that the wildlife treasures of Kananaskis Country can be maintained. For grizzlies to exist, it is essential that their habitat be maintained along with the security they need to use it. For safety of both humans and grizzlies, human activity must be restricted in areas of major significance to bears.

6.0 SUMMARY AND CONCLUSIONS

Twenty-five grizzly bears were captured and immobilized 46 times between 1980 and 1984. Trap-nights/capture averaged 93 in the Highwood trapping area and 1358 in the Sheep. Twenty-four individuals (18 males and 6 females) were weighed, measured, marked, and released. Twenty-one were radio collared. Bears were captured in spring-activated Aldrich foot snares and immobilized with a 1:1 mixture of ketamine hydrochloride and xylazine hydrochloride.

Age structure evaluation indicates adult (6 years and over):subadult (3–5 years) ratios averaged 1.25:1 for males and 2.75:1 for females. A reasonable proportion of older bears were present, and in 1980 the age structure was reasonably balanced between cub, subadult, and adult groups. Cubs (C, 1, and 2 years) and subadults (3, 4, and 5 years) accounted for 33.3% and 29.2%, respectively, of the marked population in 1980, indicating that production had been reasonably good.

Marked bears, all 2 years and older, suffered a known average mortality of 6.6%/year: 9.8% for males and 3.4% for females. As no cubs-of-the-year nor yearlings were marked, these figures provide no measure of their mortality. All mortalities were man-caused: 6(2/3) were sport hunting kills, half each in Alberta and British Columbia, and 3 (1/3) were self-defensive actions. In addition, there was 1 research mortality which is excluded from the percentage calculations. No natural mortality was found.

Total mortality indicated by these data should not be excessive, as an overall rate of 10–11%

probably would be acceptable. Hunting regulations protective of females had been effective, for no marked females had died through legal sport hunting. If female mortality remains low, the population should have the potential to expand. Most mortality of marked bears (2/3) occurred outside Kananaskis Country. Inside, mortality averaged 0.625 bears/year — about 1.25% of Kananaskis Country bears annually.

Grizzly bears occurred throughout the contiguously forested area of southwestern Alberta, but they were most common west of the front ranges in more remote areas least affected by human activity. Most spent some time in British Columbia. Home ranges of males were much larger than those of females. Complete annual home ranges averaged 1183 km^2 for males and 179 km^2 for females, but variability was great. Their areas ranged from 902–1407 km^2 for males and from 91–345 km^2 for females. The multi-annual home ranges of most bears were considerably larger than their annual ones. Individual grizzlies often used substantially different though usually adjacent or partly overlapping ranges from one year to the next. Home ranges of different grizzlies, particularly males, overlapped substantially. Female ranges appeared more mutually exclusive.

Direct observation yielded a known minimum population of 27 grizzly bears in 1980 and 26 in 1983; however, the actual population would have been larger. A modified Petersen estimate of the number of male grizzlies (over 3 years old and in contact with the traps) added to the numbers of females and young (implied from other information) equalled 77 bears — 24.1 males, 27.5 females, and 25.2 young. A similar estimate of the number of females added to the numbers of males and young (implied from other information) was 15 bears — 5.2 females, 4.4 males, and 5.7 young. These estimates produced average densities of 1 bear/82 km^2 in the multi-annual home range polygon for marked males and 1 bear/69 km^2 in the better habitat of the multi-annual home range polygon for marked females. These figures are probably minimal. The densities are averages for large areas, but densities actually vary between locales. In general, densities were greater west of the front ranges but much less to the east in the foothills. In spite of bears immigrating from the west, grizzly density in the foothills likely will remain low because of high mortality there associated with human conflicts.

Based on the density of 1 bear/82 km^2, the grizzly population in Kananaskis Country is about 50 bears. Although only of gross value, comparison with other studies suggests densities of grizzlies in the Kananaskis area were higher than those found in other Alberta areas. They were similar to densities reported for the Mackenzie Mountains, Northwest Territories and Yellowstone Park, Wyoming.

The welfare of Kananaskis area grizzly bears is dependent on decisions by various agencies in both Alberta and British Columbia. Future research should evaluate mortality of cub and yearling grizzlies, and management must maintain constant monitoring of mortality to ensure it remains low and focused on males. Protection of females must remain a high priority to ensure their mortality remains low and the population strong.

Sport harvest must be controlled carefully since it caused most grizzly bear mortality, and cooperation between Alberta and British Columbia is essential in this regard. Limited sport hunting can be maintained in Kananaskis Country and sustained by the overall population; however, increased harvest there may necessitate a reduced harvest outside Kananaskis.

The grizzly population, particularly if it increases, can be expected to affect livestock operations. In better grizzly habitats west of the front ranges, such operations should be adjusted as needed to minimize conflicts. Near private lands along the foothills, lower grizzly densities should be maintained through sport hunting in order to minimize livestock depredation.

For safety of both bears and people, the presence of grizzlies must be considered at all times in plans for human developments and activities in the Kananaskis area and generally throughout the mountains and foothills of southern Alberta. Developments and activities must avoid important grizzly habitat to minimize the chances of conflict. Mortalities of grizzlies caused by human self-defensive actions need detailed study to find means of minimizing such confrontations and mortalities.

With human impacts on wildland habitats increasing steadily, greater efforts will be required in the future to maintain grizzlies in this area. Human activities must be carefully channelled and restricted to maintain adequate habitat for grizzlies and safety for both bears and people.

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APPENDIX

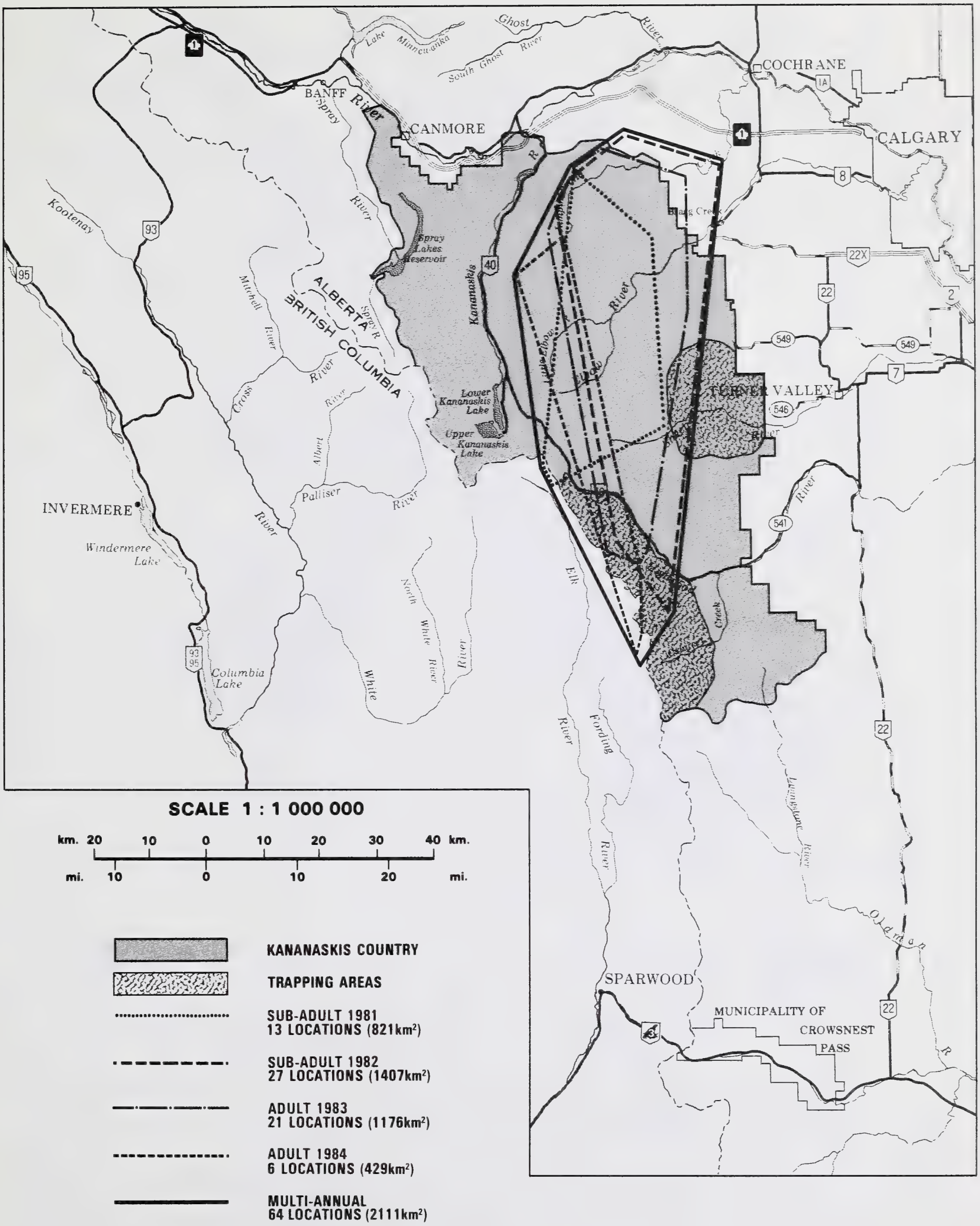

Fig. 5. Minimum area polygons depicting the home range of male grizzly S1.

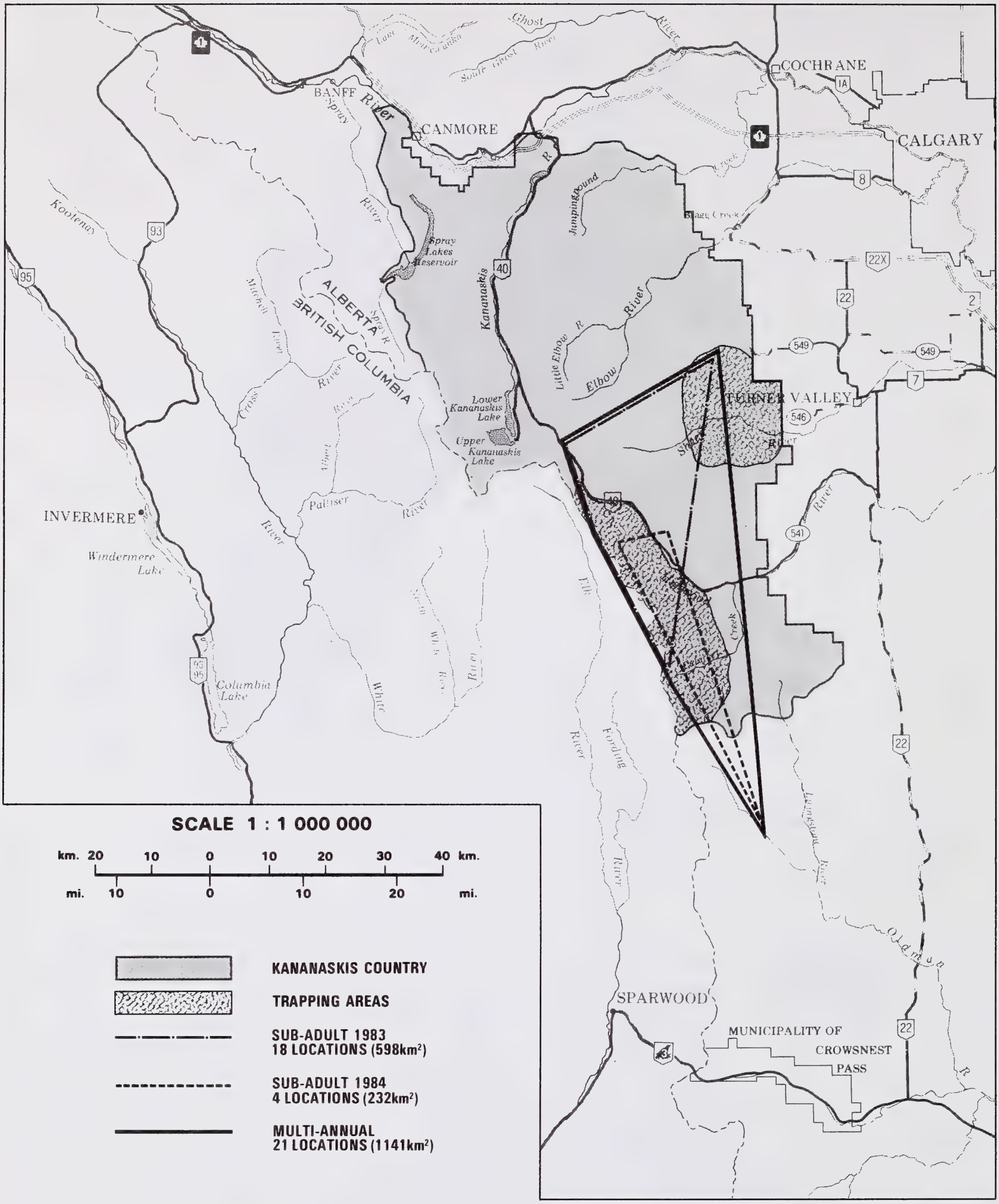

Fig. 6. Minimum area polygons depicting the home range of male grizzly S2.

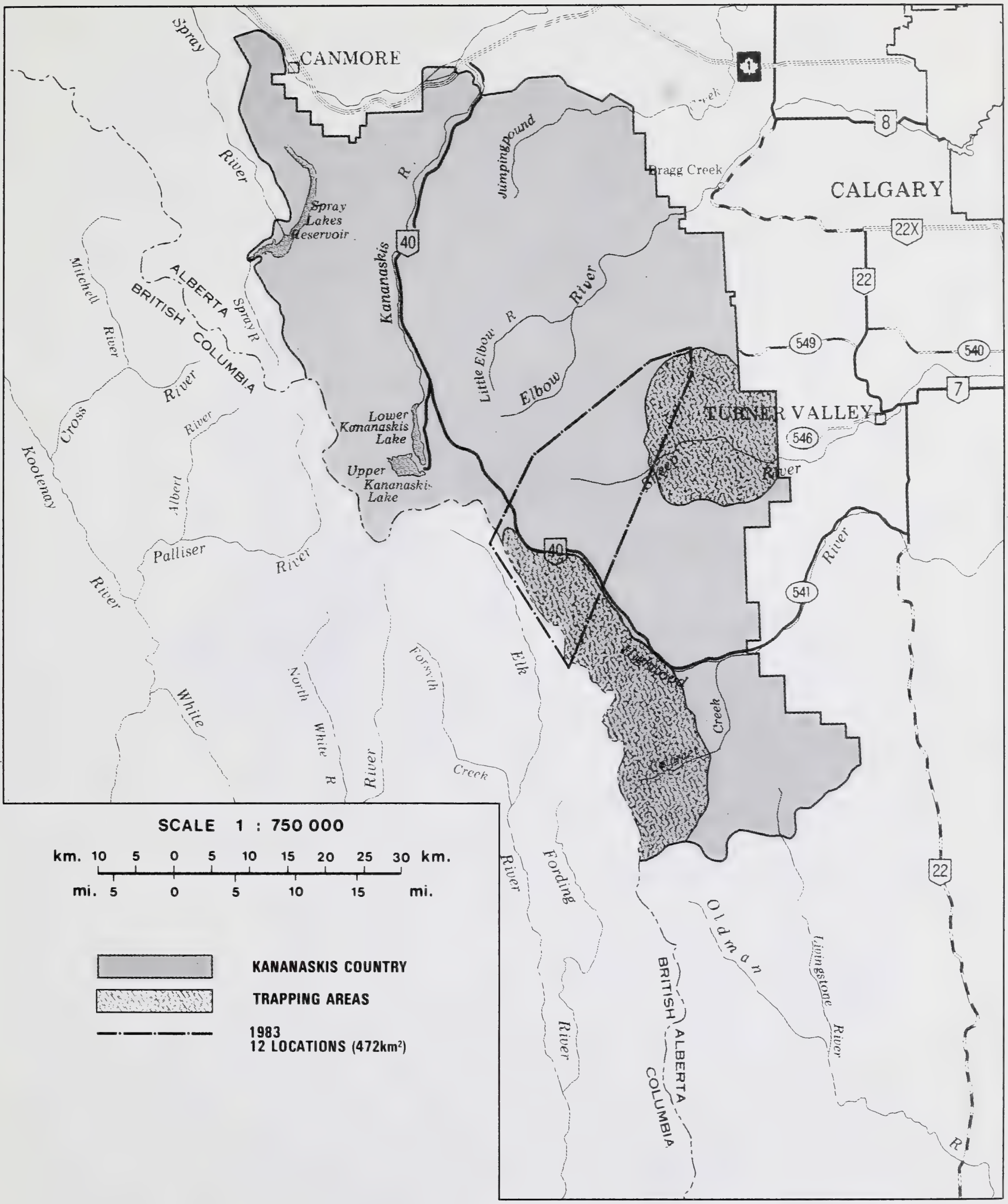

Fig. 7. Minimum area polygon depicting the home range of subadult male grizzly S3.

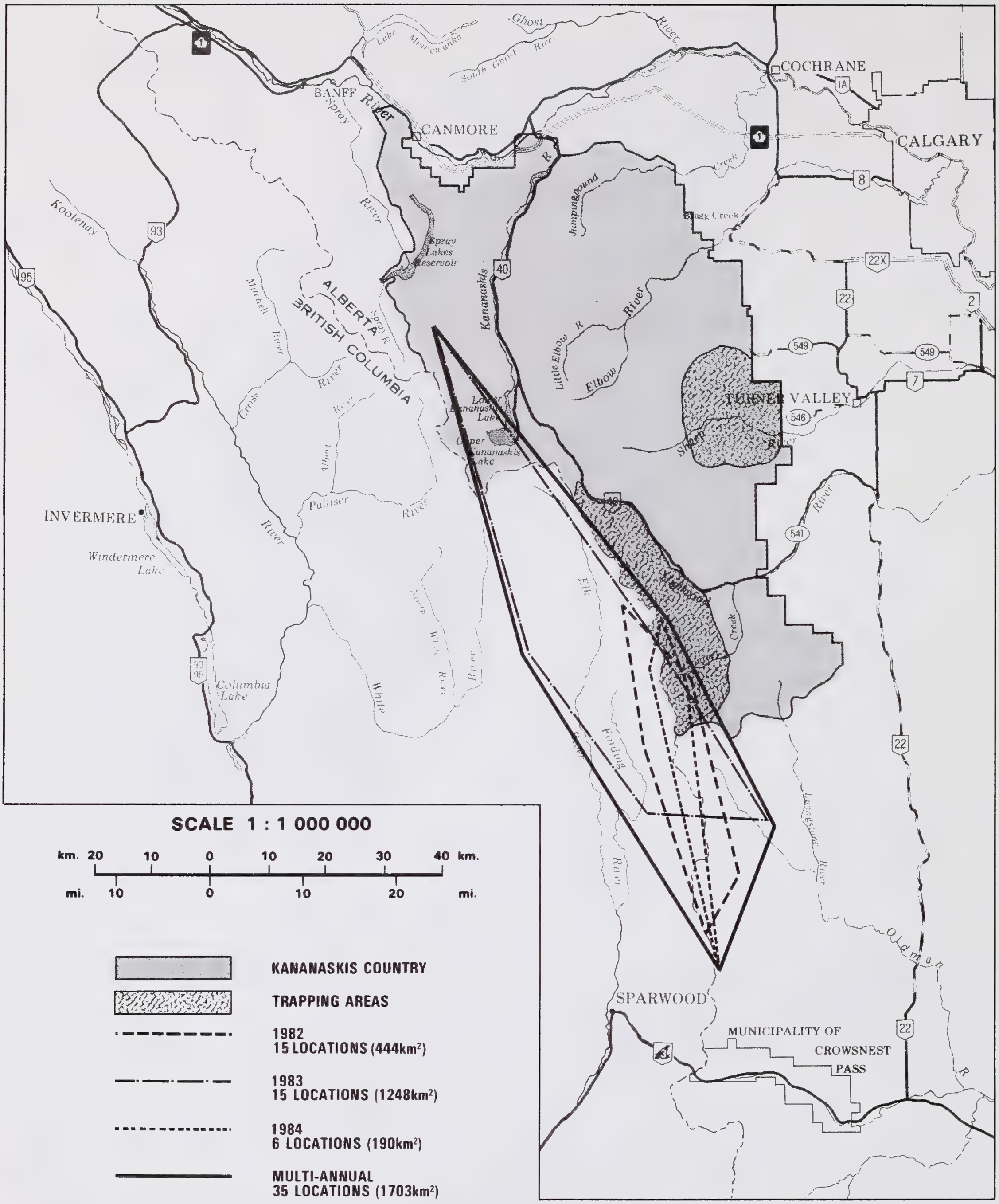

Fig. 8. Minimum area polygons depicting the home range of adult male grizzly H1.

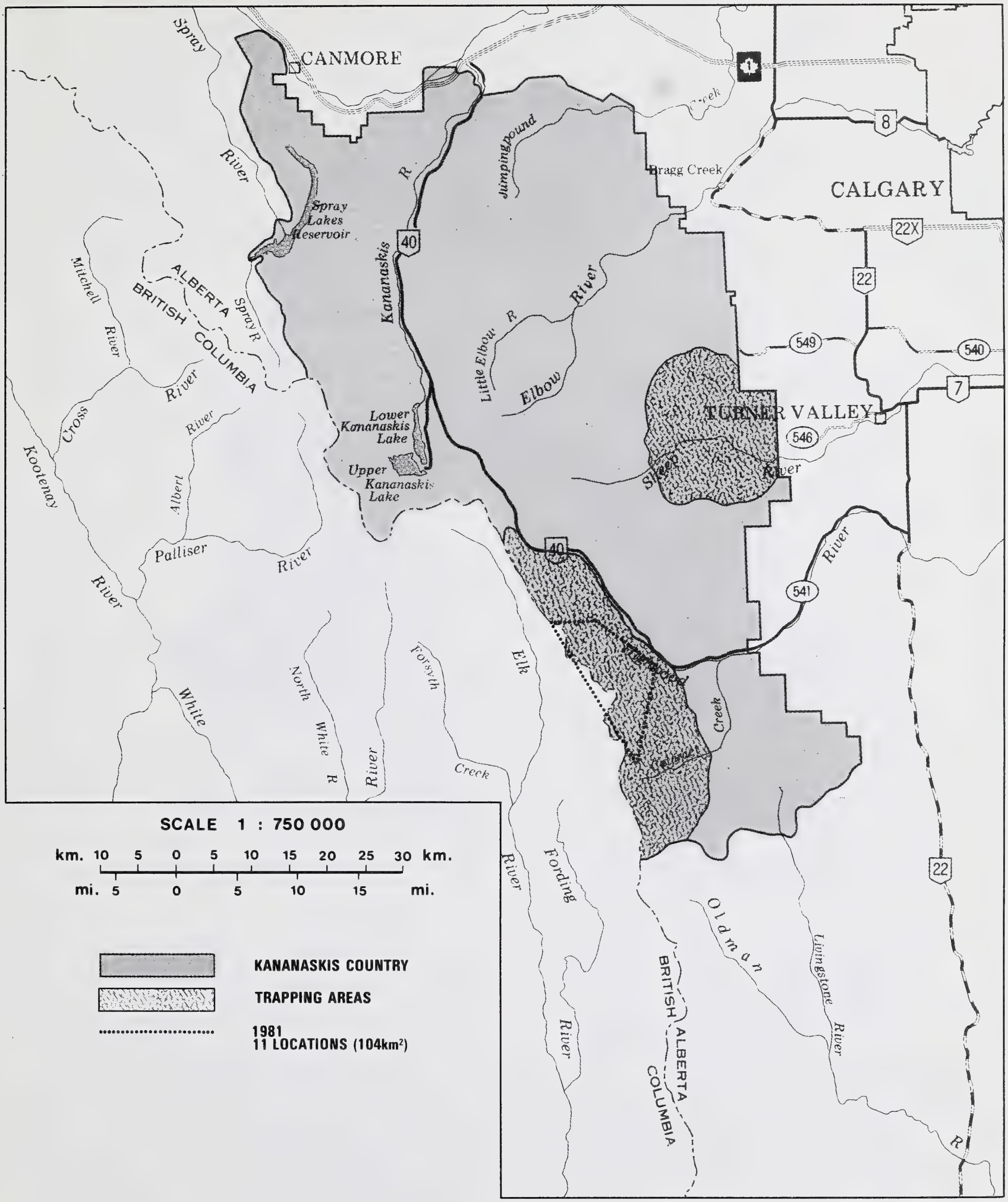

Fig. 9. Minimum area polygon depicting the home range of subadult male grizzly H6.

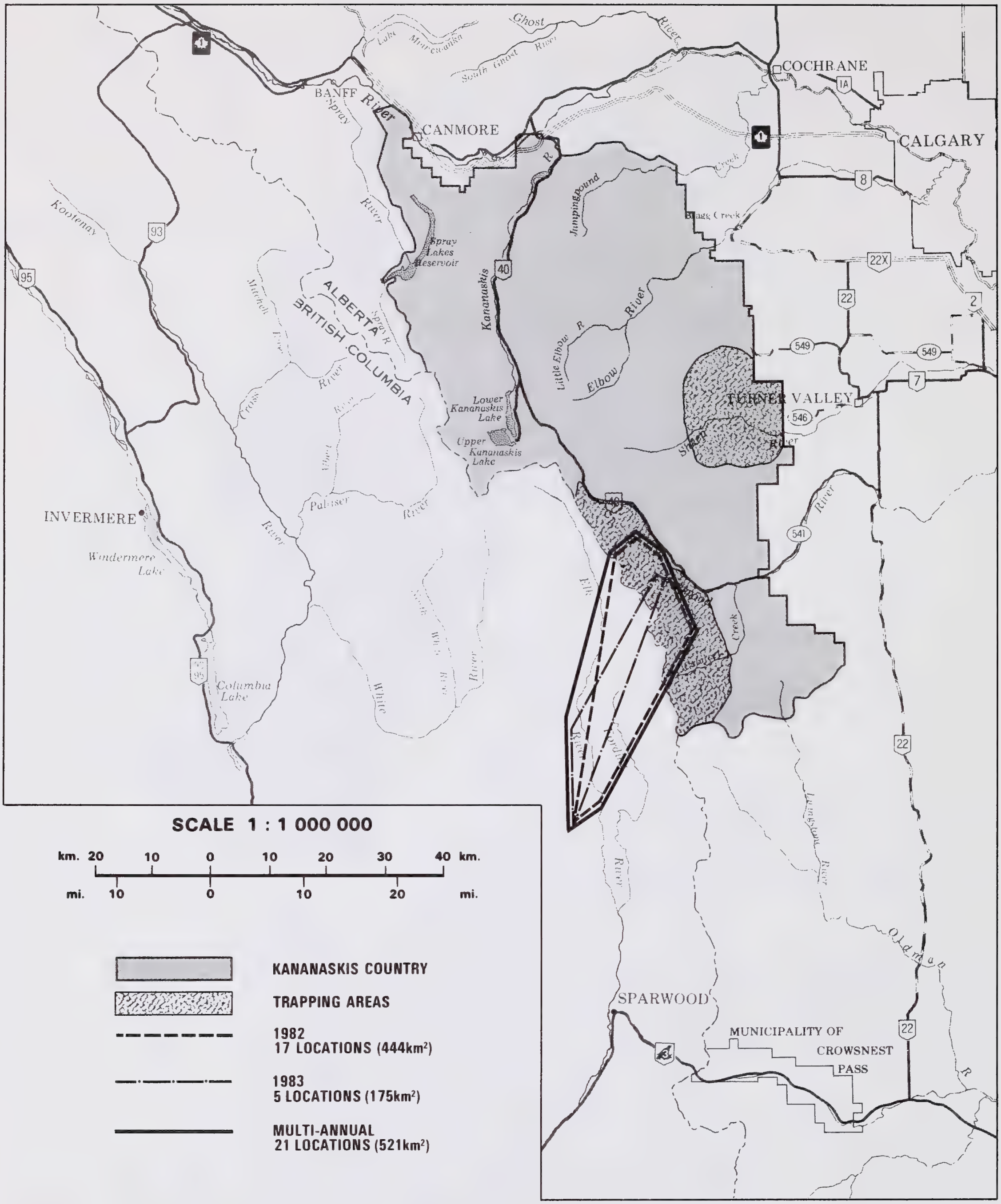

Fig. 10. Minimum are polygons depicting the home range of subadult male grizzly H10.

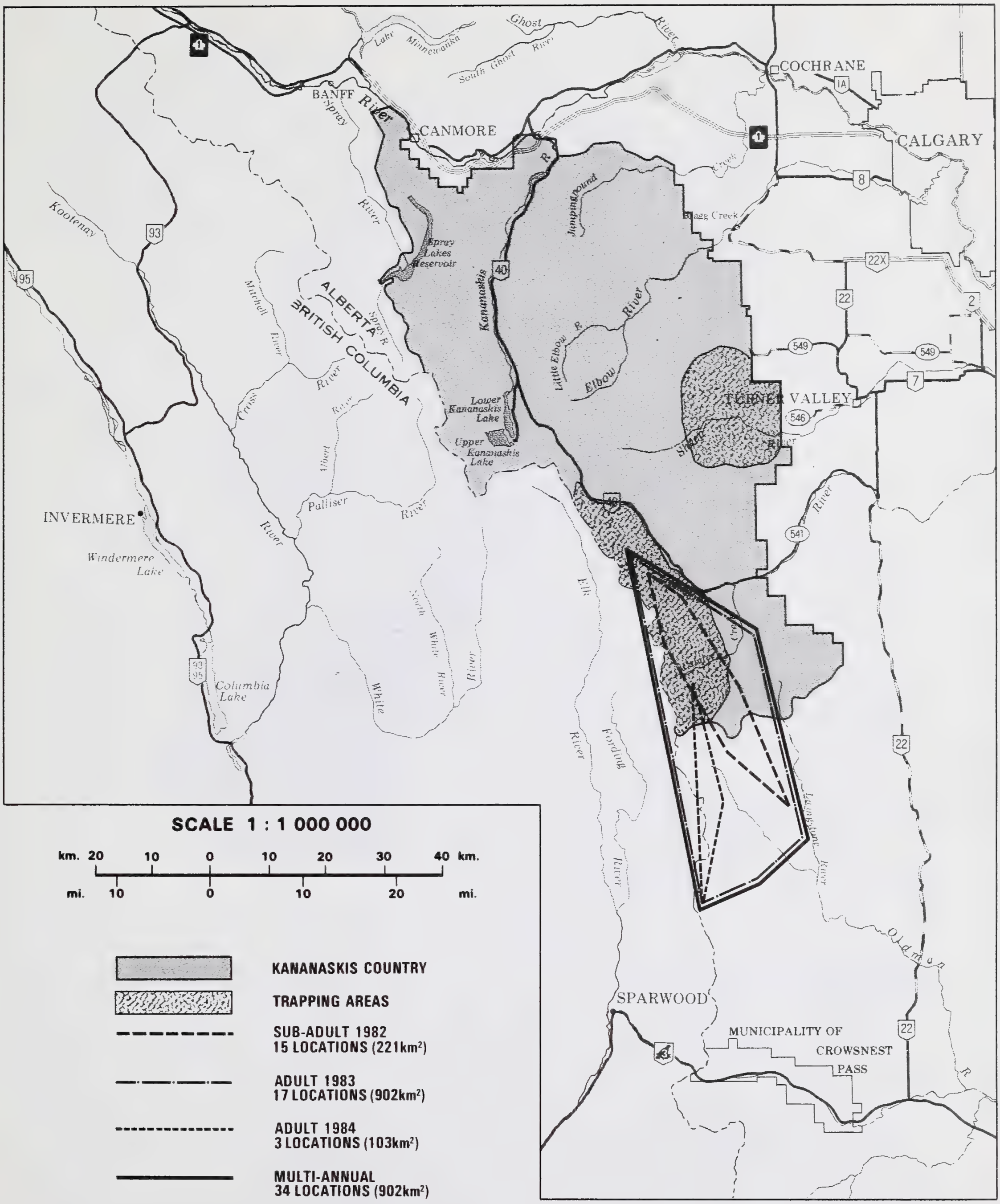

Fig. 11. Minimum area polygons depicting the home range of male grizzly H14.

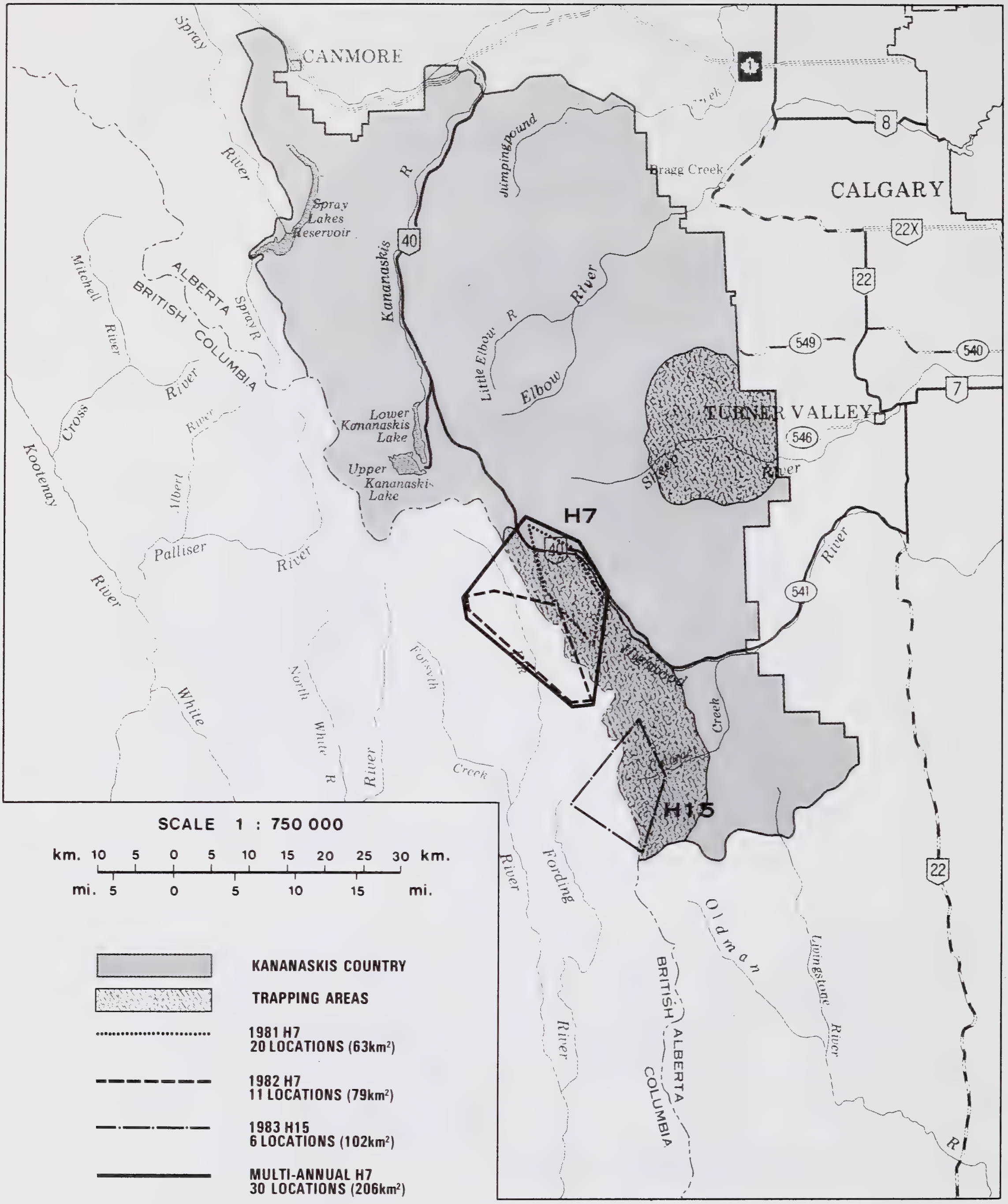

Fig. 12. Minimum area polygons depicting the home ranges of adult male grizzlies H7 and H15.

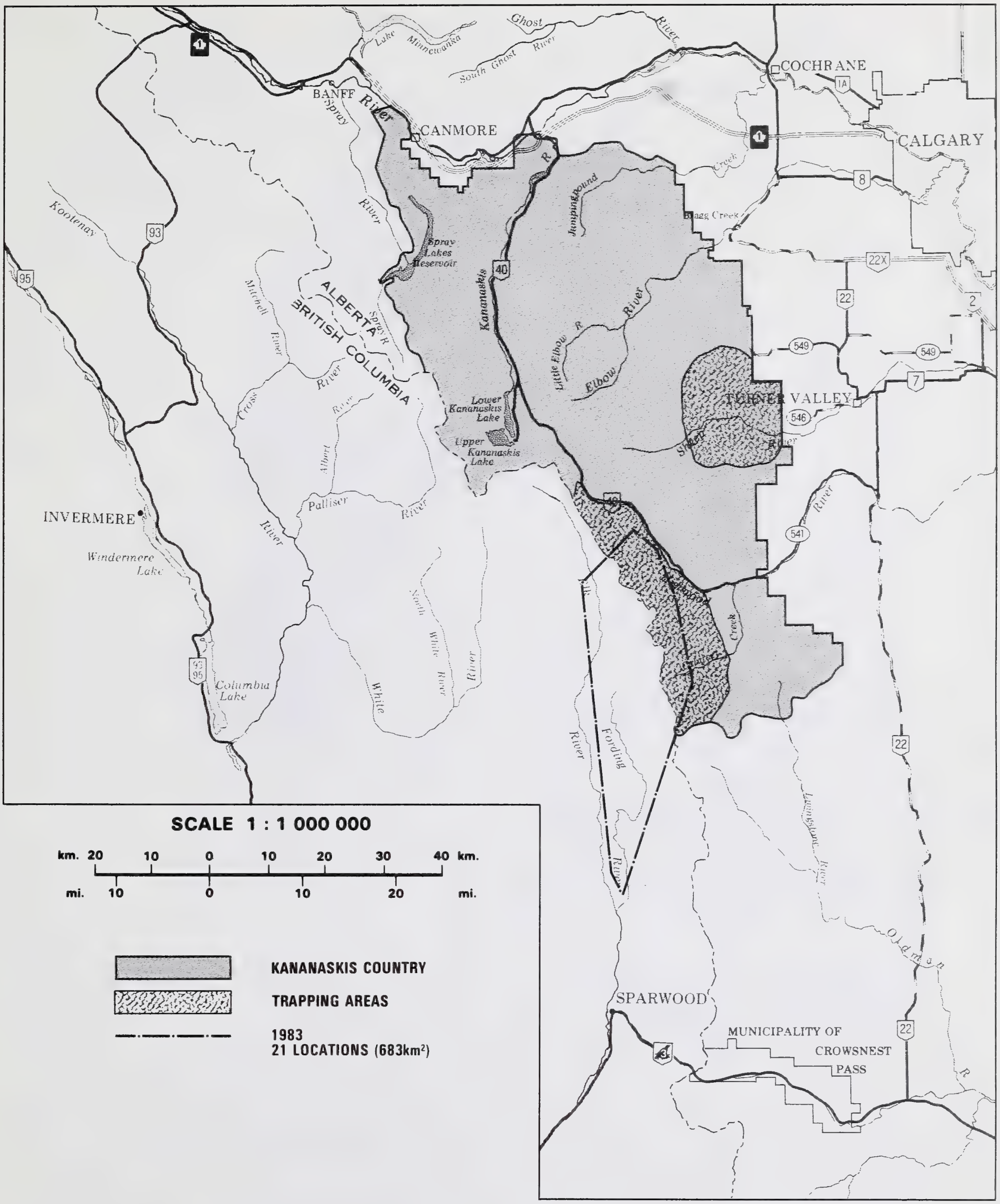

Fig. 13. Minimum area polygon depicting the home range of subadult male grizzly H16.

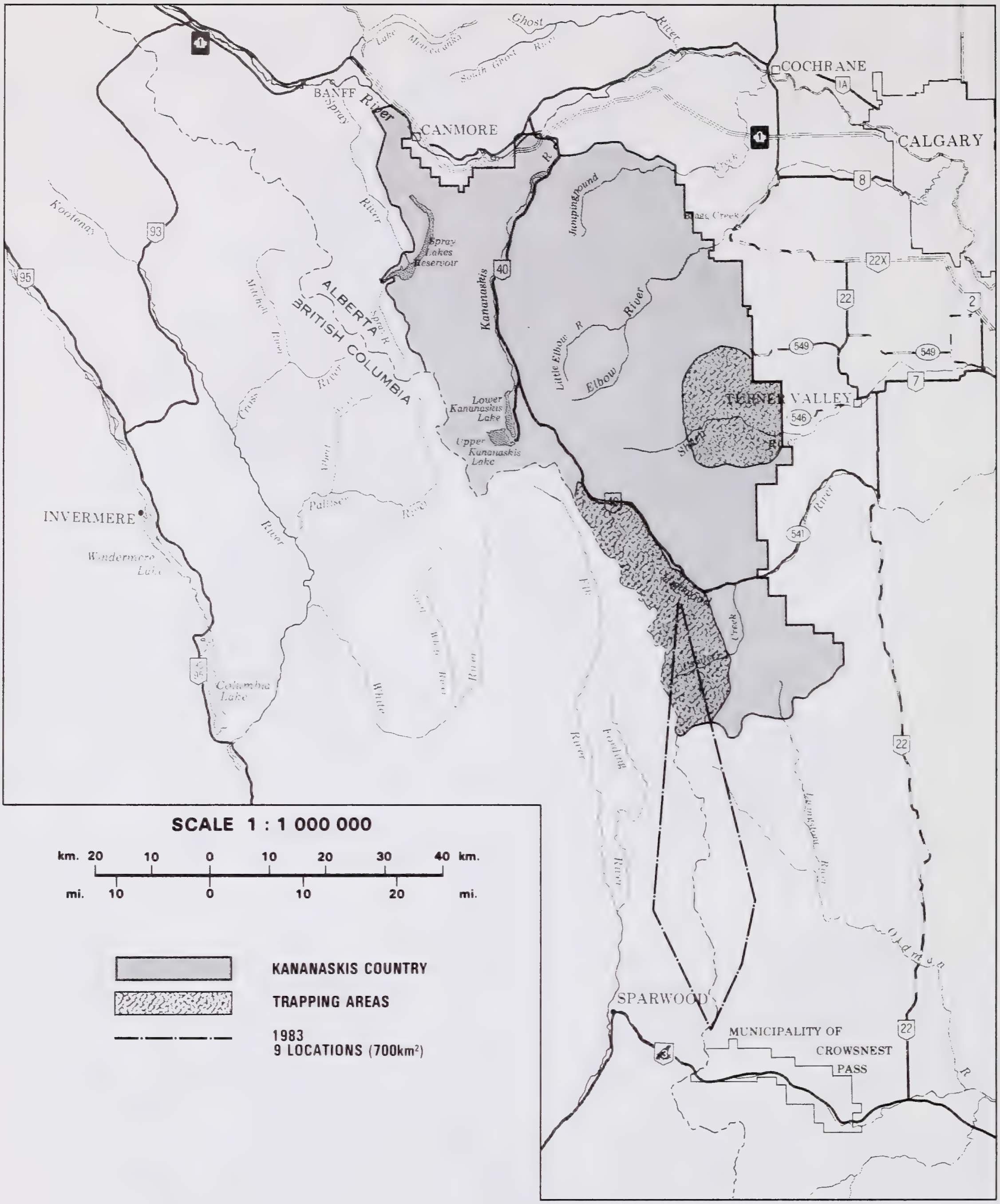

Fig. 14. Minimum area polygon depicting the home range of adult male grizzly H17.

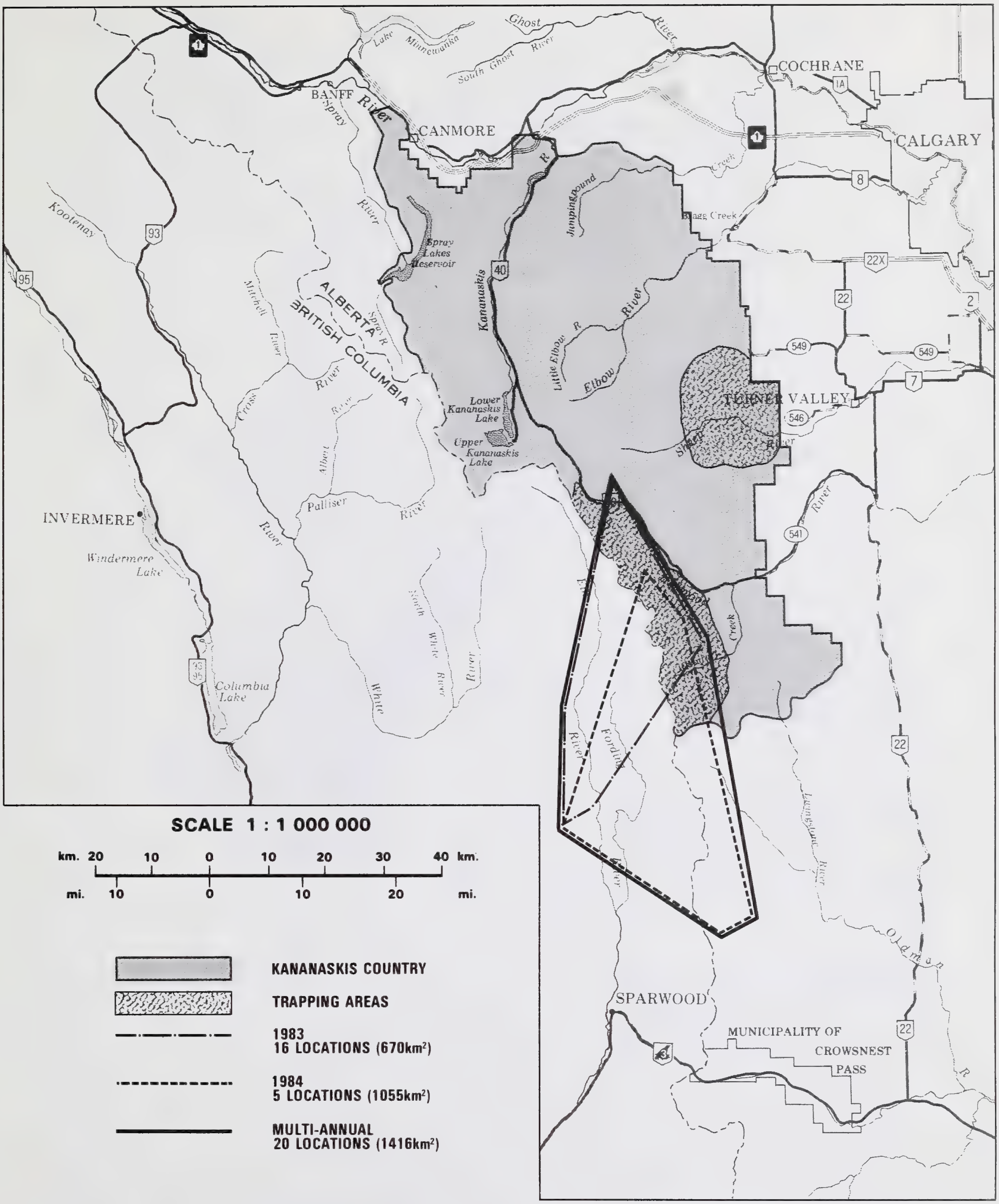

Fig. 15. Minimum area polygons depicting the home range of subadult male grizzly H18.

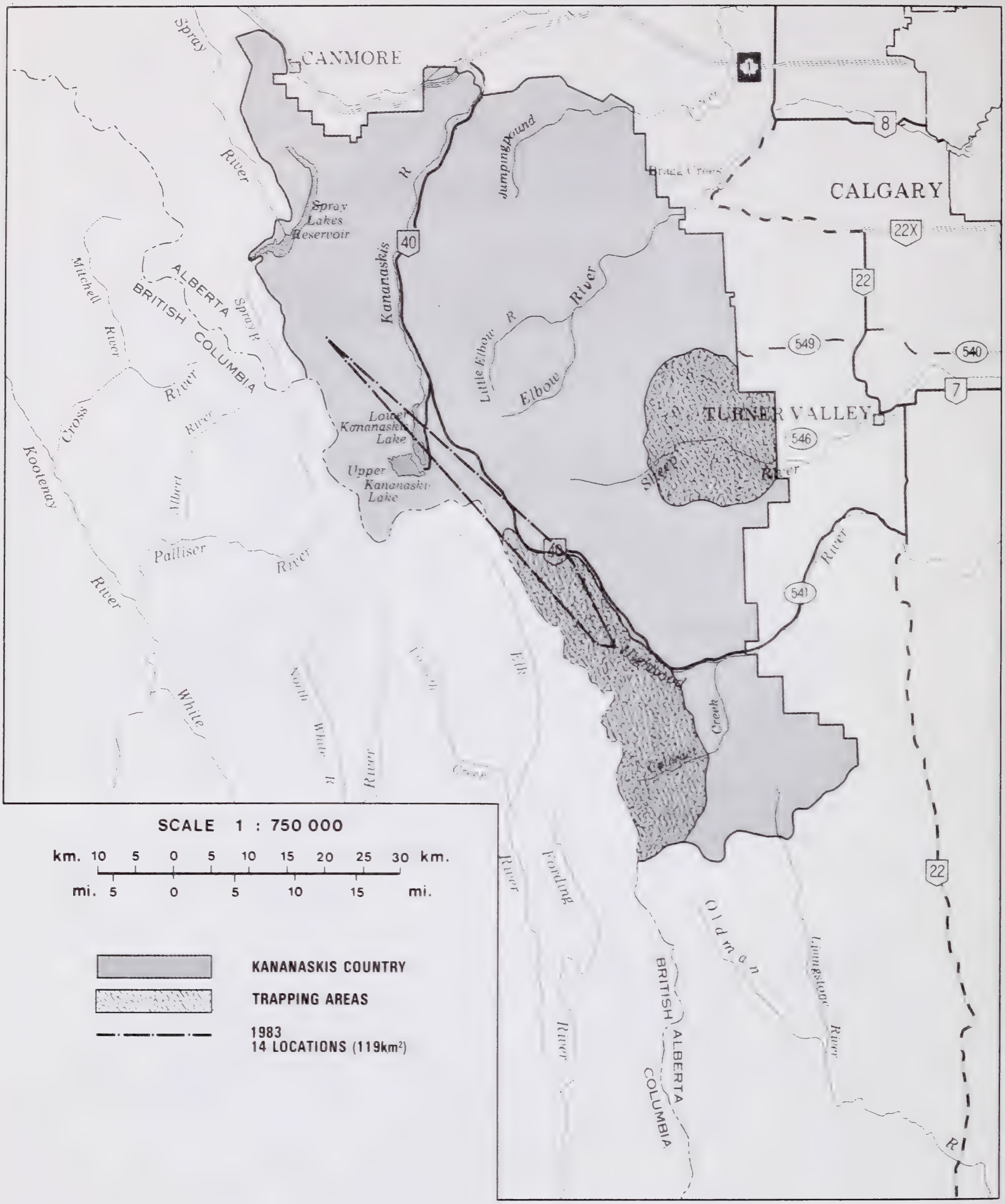

Fig. 16. Minimum area polygon depicting the home range of adult male grizzly H19.

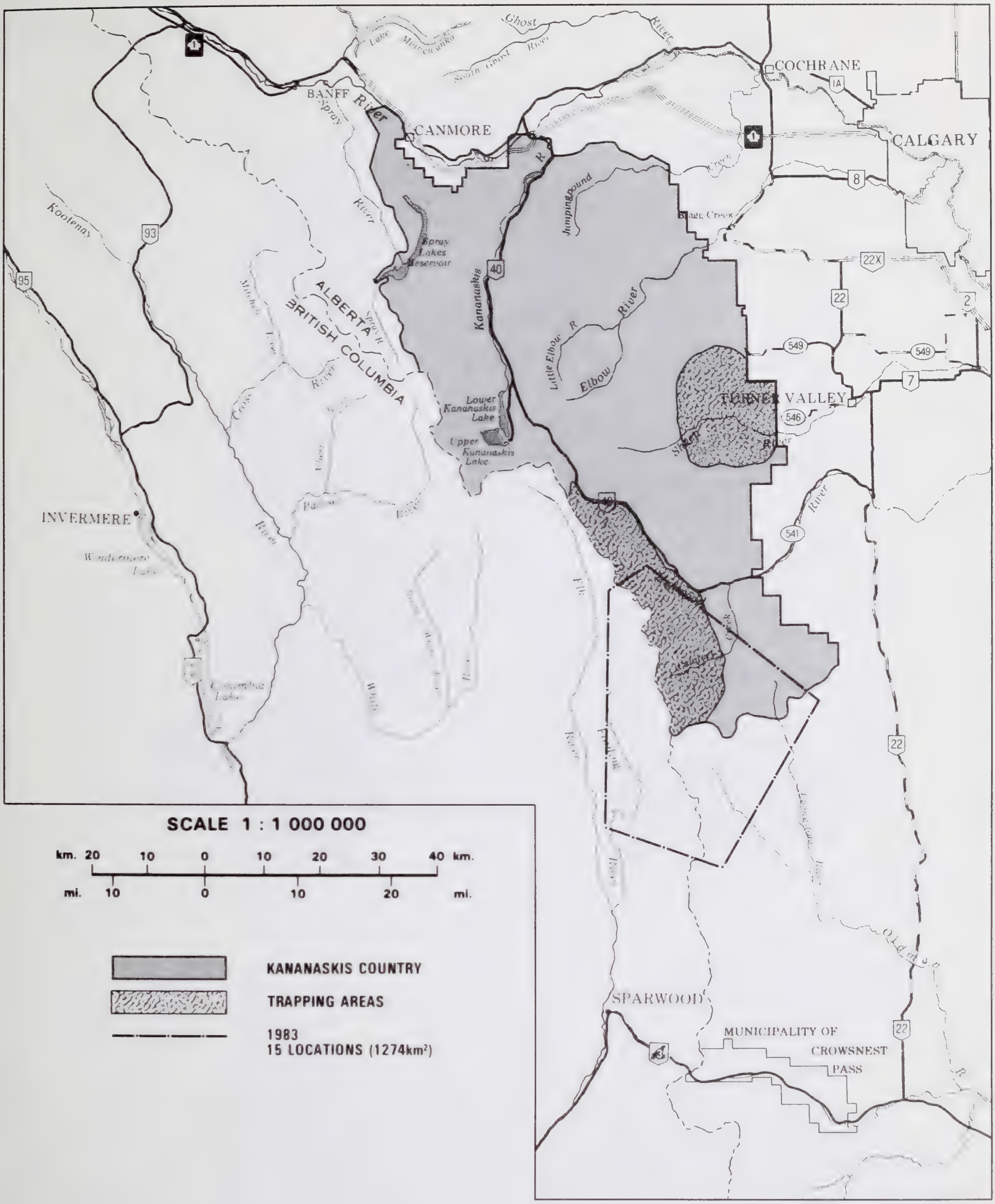

Fig. 17. Minimum area polygon depicting the home range of subadult male grizzly H21.

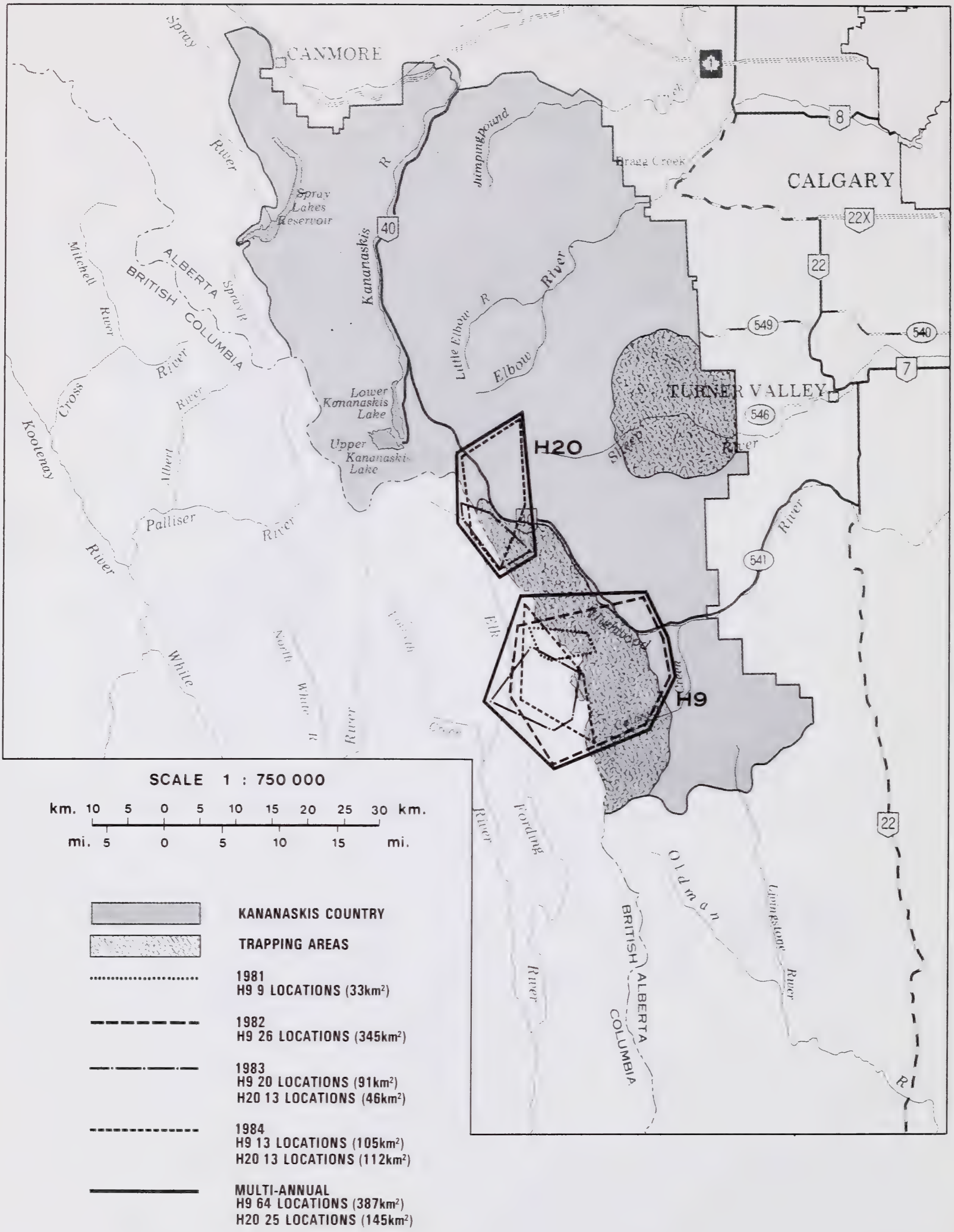

Fig. 18. Minimum area polygons depicting the home ranges of adult female grizzlies H9 and H20.

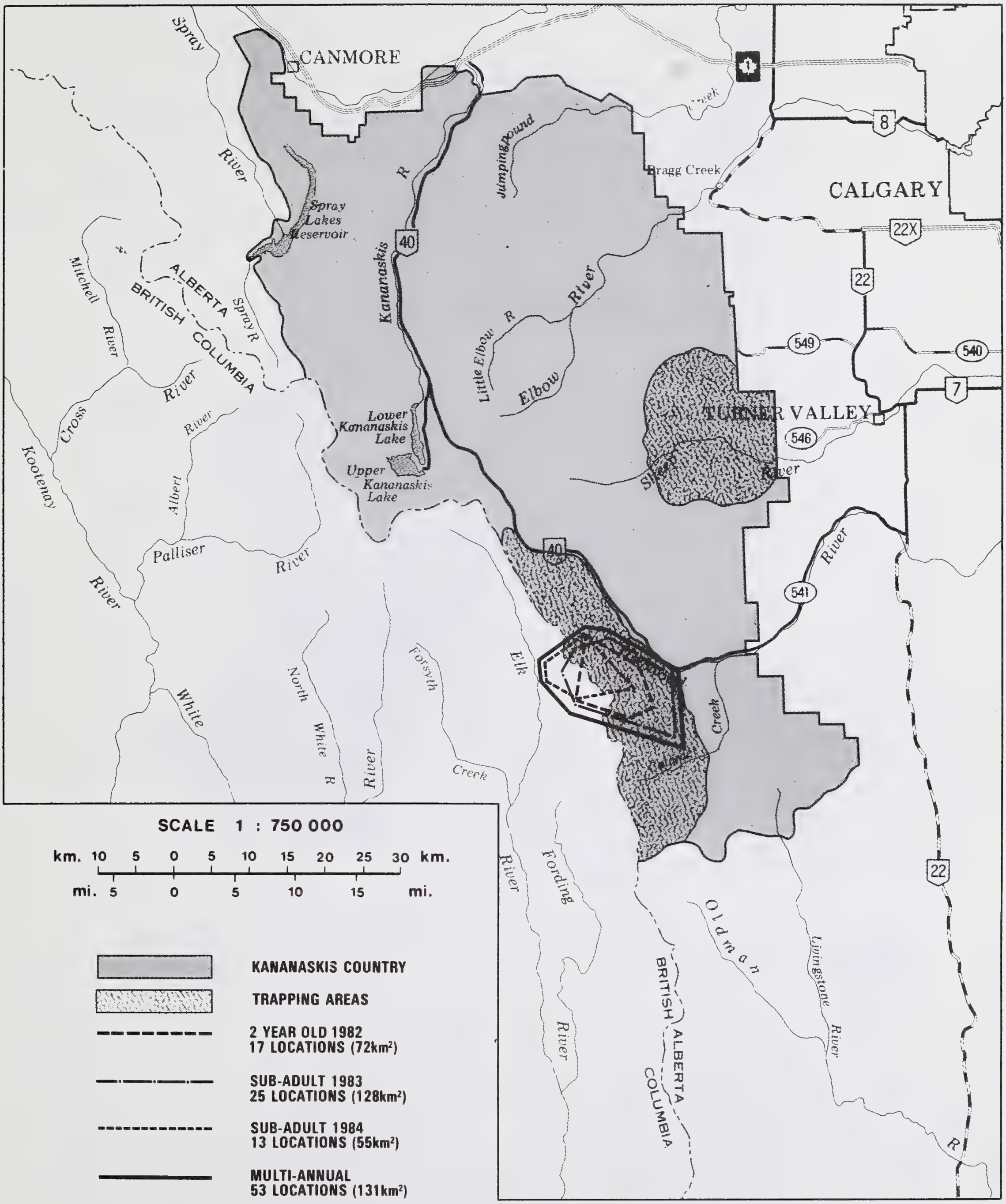

Fig. 19. Minimum area polygons depicting the home range of female grizzly H11.

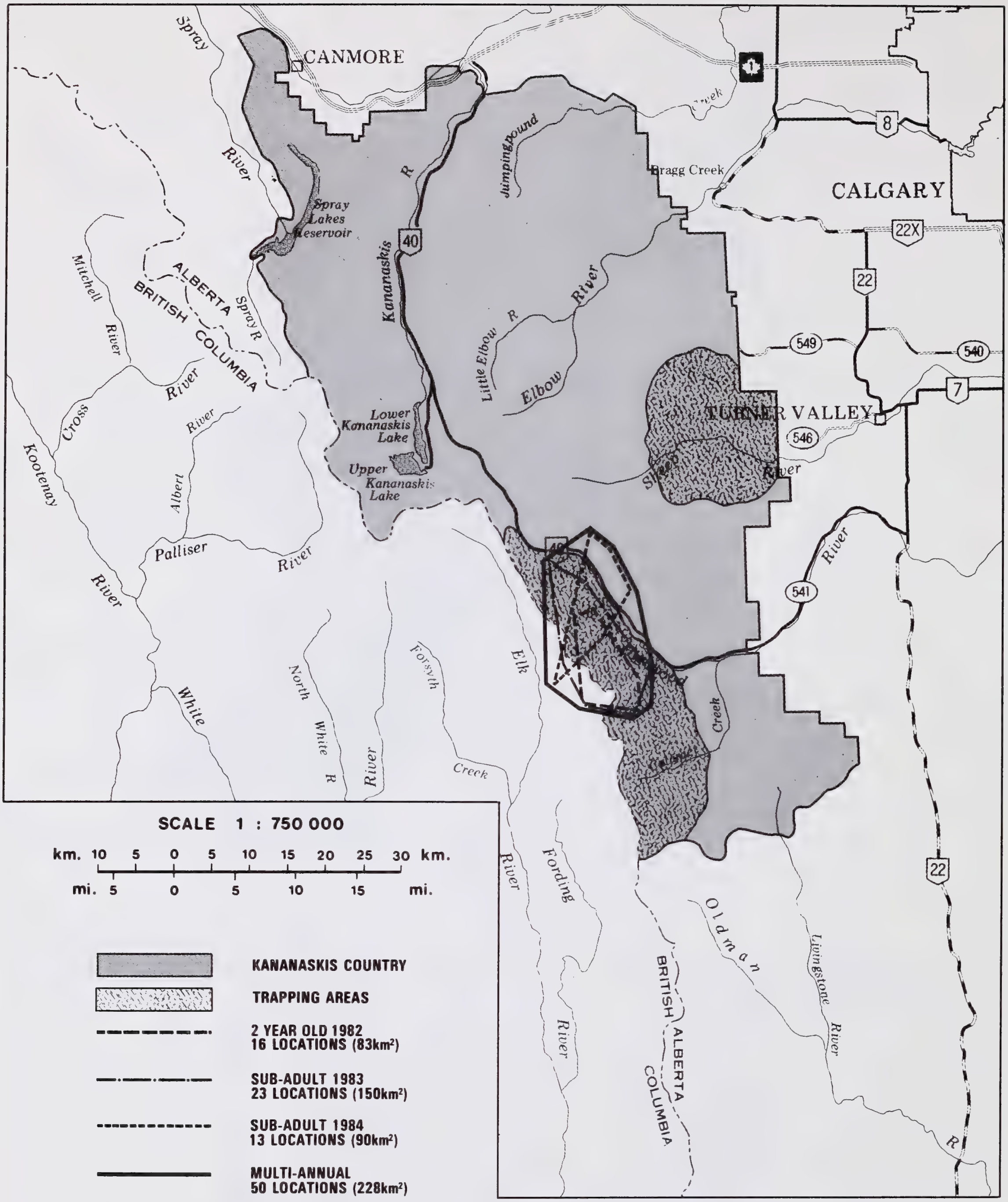

Fig. 20. Minimum area polygons depicting the home range of female grizzly H12.

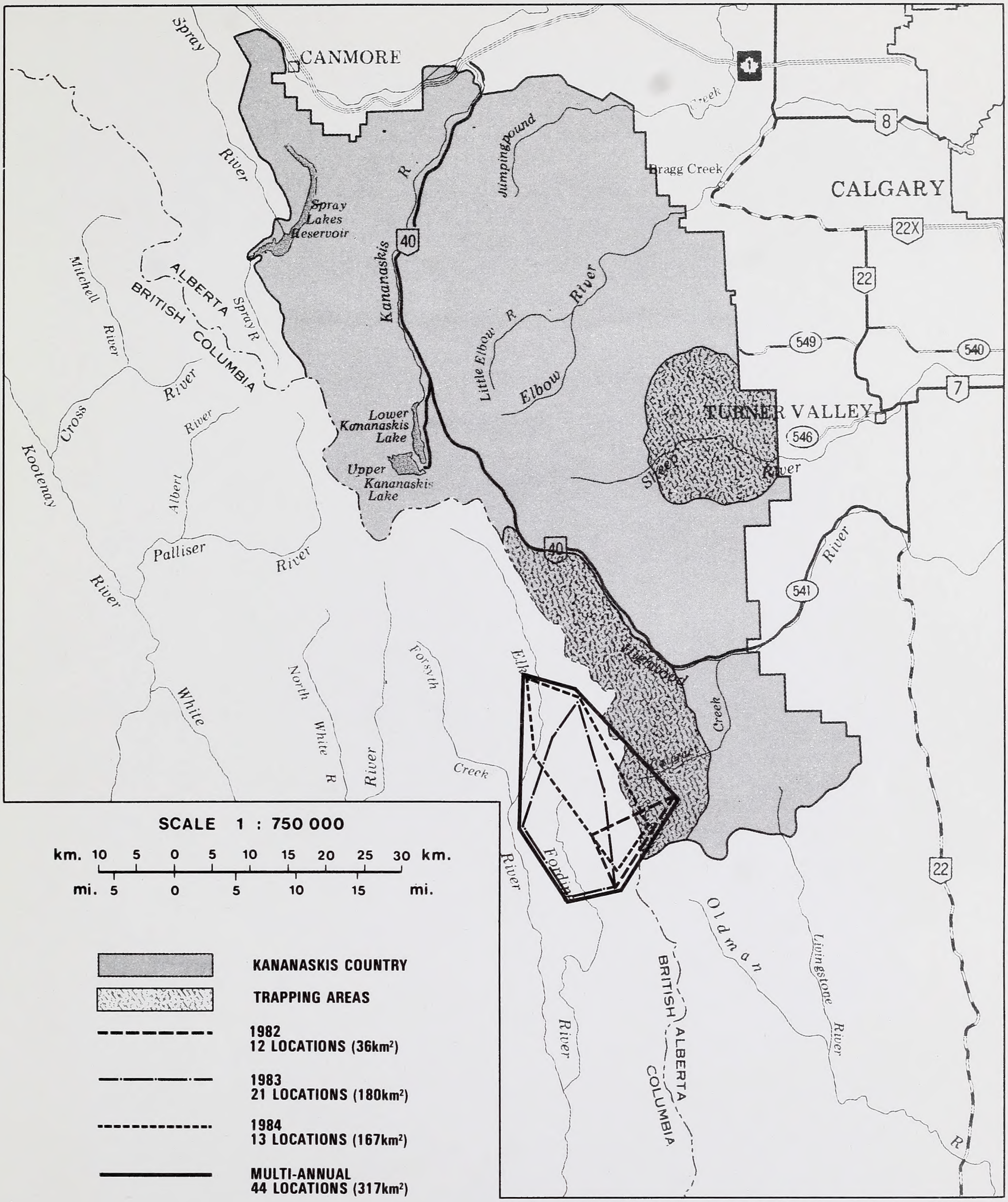

Fig. 21. MInimum area polygons depicting the home range of adult female grizzly H13.

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